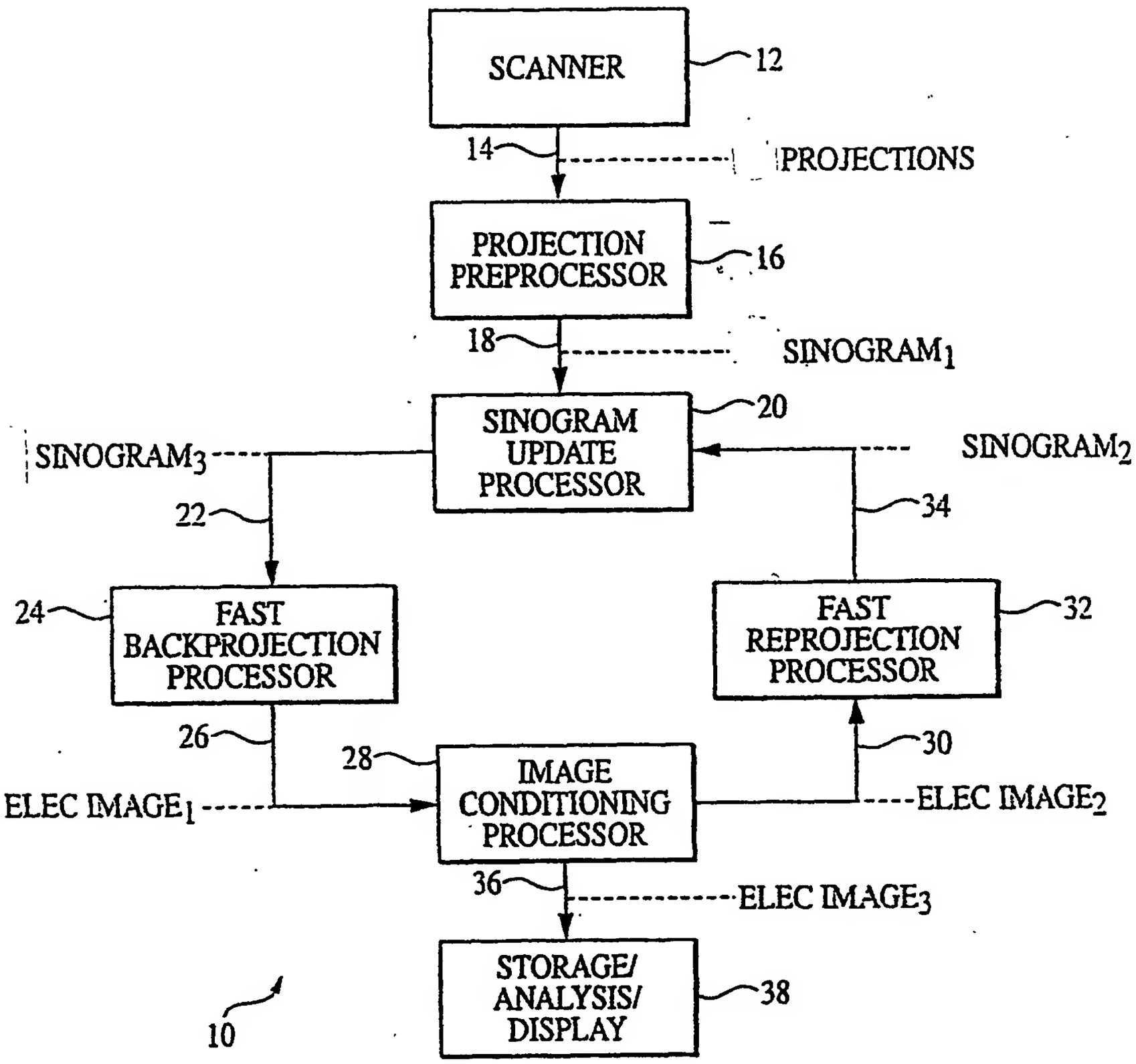

SCANNER
12
14
PROJECTIONS
PROJECTION PREPROCESSOR
16
18
SINOGRAM1
SINOGRAM UPDATE PROCESSOR
20
SINOGRAM3
SINOGRAM2
22
34
24
FAST BACKPROJECTION PROCESSOR
FAST REPROJECTION PROCESSOR
32
26
28
30
ELEC IMAGE1
IMAGE CONDITIONING PROCESSOR
ELEC IMAGE2
36
ELEC IMAGE3
STORAGE/ ANALYSIS/ DISPLAY
38
10

FIG. 1

FIG. 2A

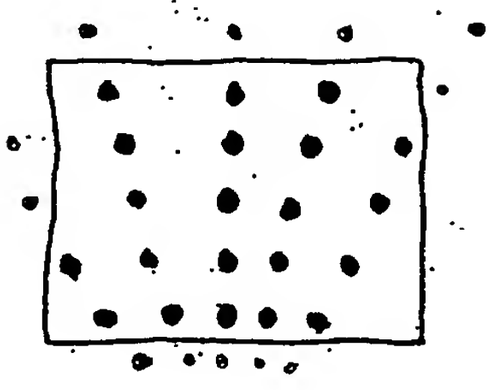
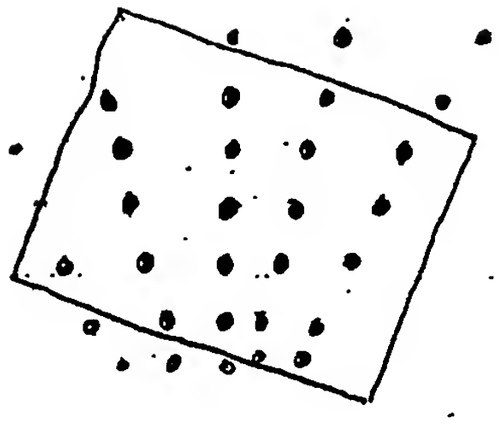


FIG. 2B



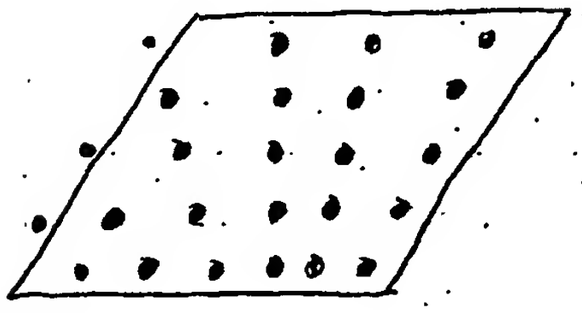


FIG. 2C

FIG.3A

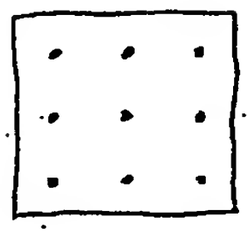
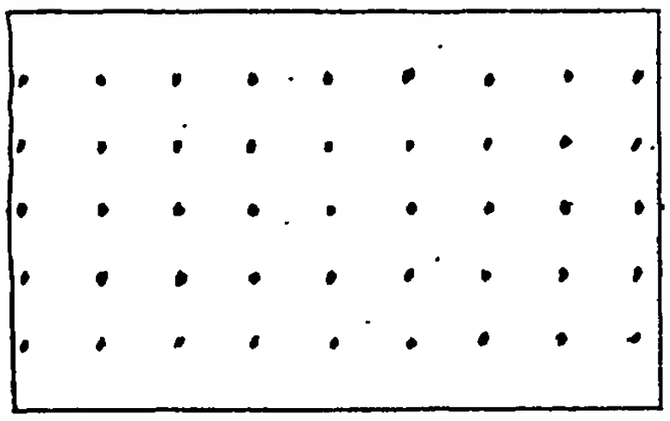


FIG.3B



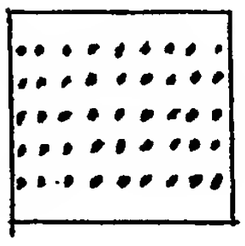
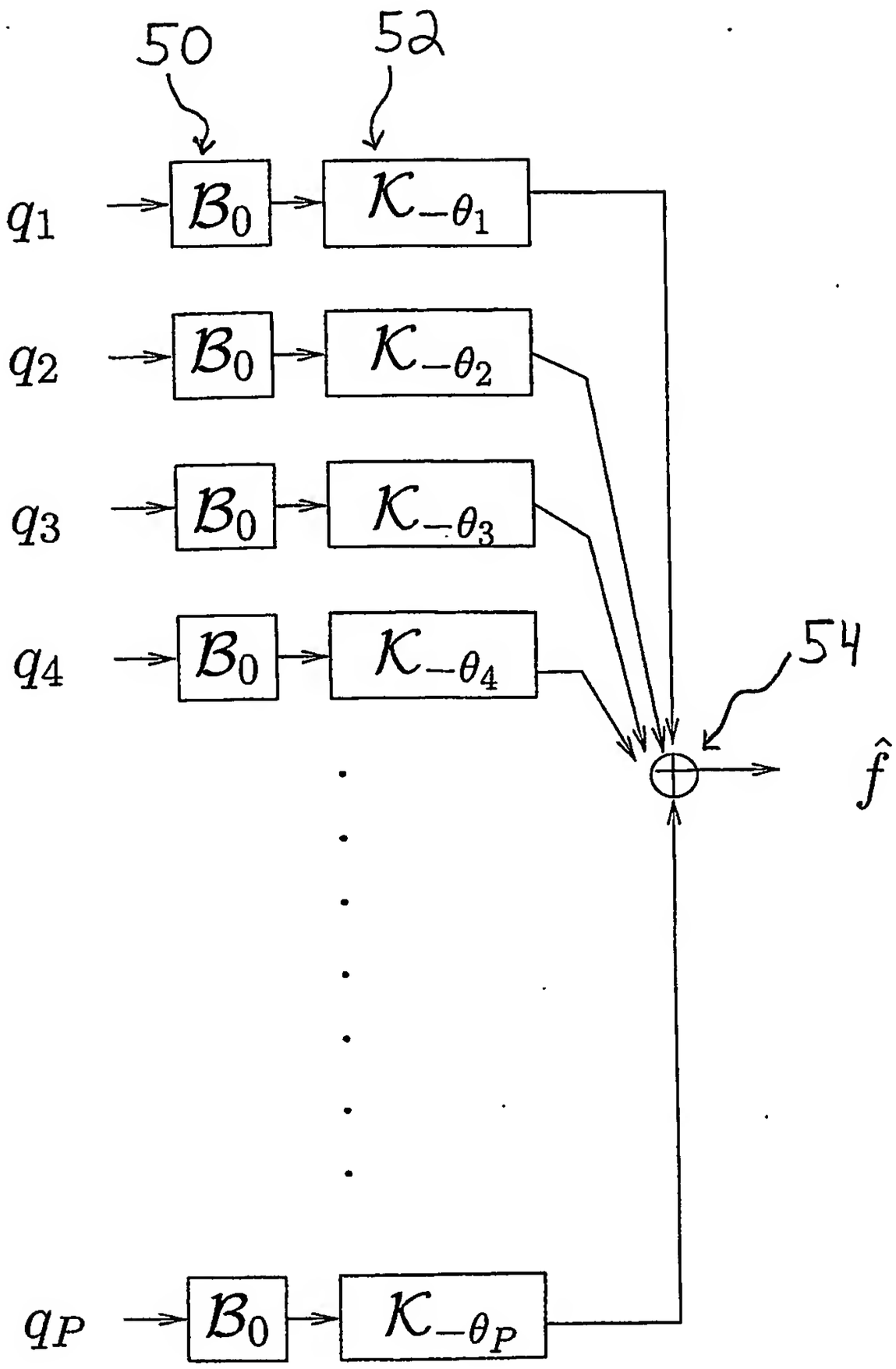


FIG.3C



PRIOR ART

FIG. 4

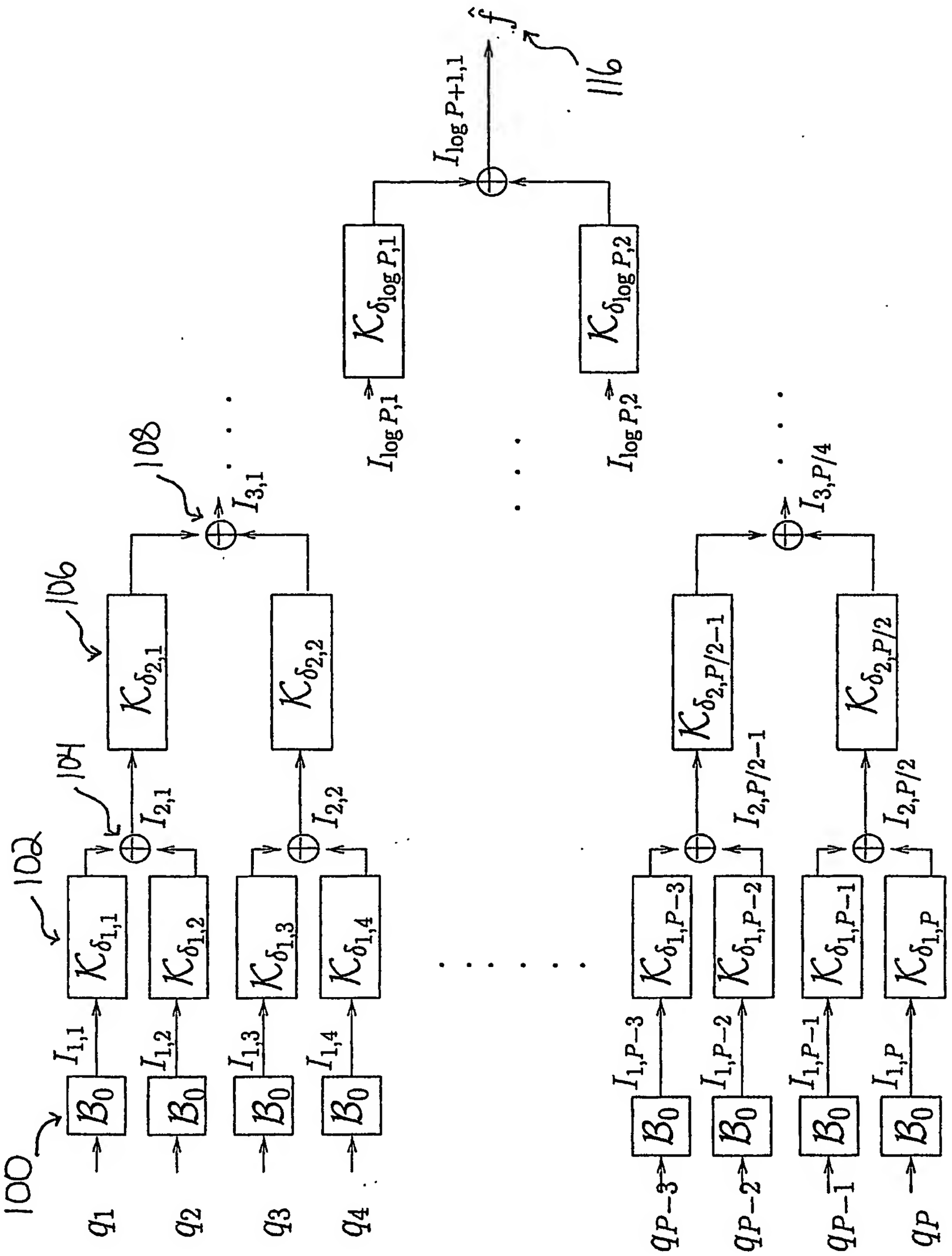
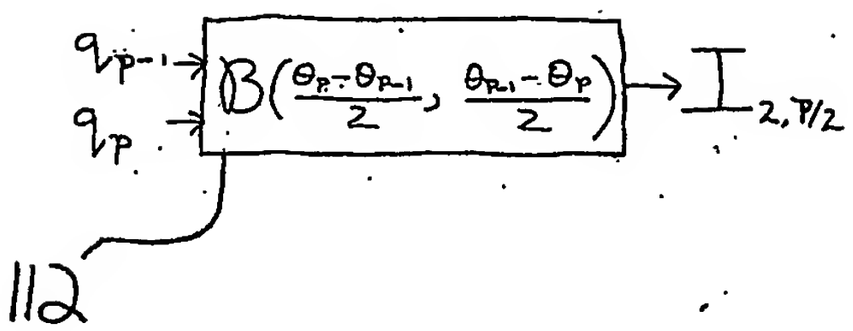

$\hat{f}$
116
$I_{\log P+1,1}$
$K_{\delta_{\log P,1}}$
$K_{\delta_{\log P,2}}$
$I_{\log P,1}$
$I_{\log P,2}$
108
$I_{3,1}$
$I_{3,P/4}$
106
$K_{\delta_{2,1}}$
$K_{\delta_{2,2}}$
$K_{\delta_{2,P/2-1}}$
$K_{\delta_{2,P/2}}$
104
$I_{2,1}$
$I_{2,2}$
$I_{2,P/2-1}$
$I_{2,P/2}$
102
$K_{\delta_{1,1}}$
$K_{\delta_{1,2}}$
$K_{\delta_{1,3}}$
$K_{\delta_{1,4}}$
$K_{\delta_{1,P-3}}$
$K_{\delta_{1,P-2}}$
$K_{\delta_{1,P-1}}$
$K_{\delta_{1,P}}$
$I_{1,1}$
$I_{1,2}$
$I_{1,3}$
$I_{1,4}$
$I_{1,P-3}$
$I_{1,P-2}$
$I_{1,P-1}$
$I_{1,P}$
B_0
100
q_1
q_2
q_3
q_4
q_{P-3}
q_{P-2}
q_{P-1}
q_P

FIG. 5A

FIG. 5B


q_{p-1}
q_p
$B\left(\frac{\theta_p-\theta_{p-1}}{2}, \frac{\theta_{p-1}-\theta_p}{2}\right)$
$I_{2,P/2}$
112

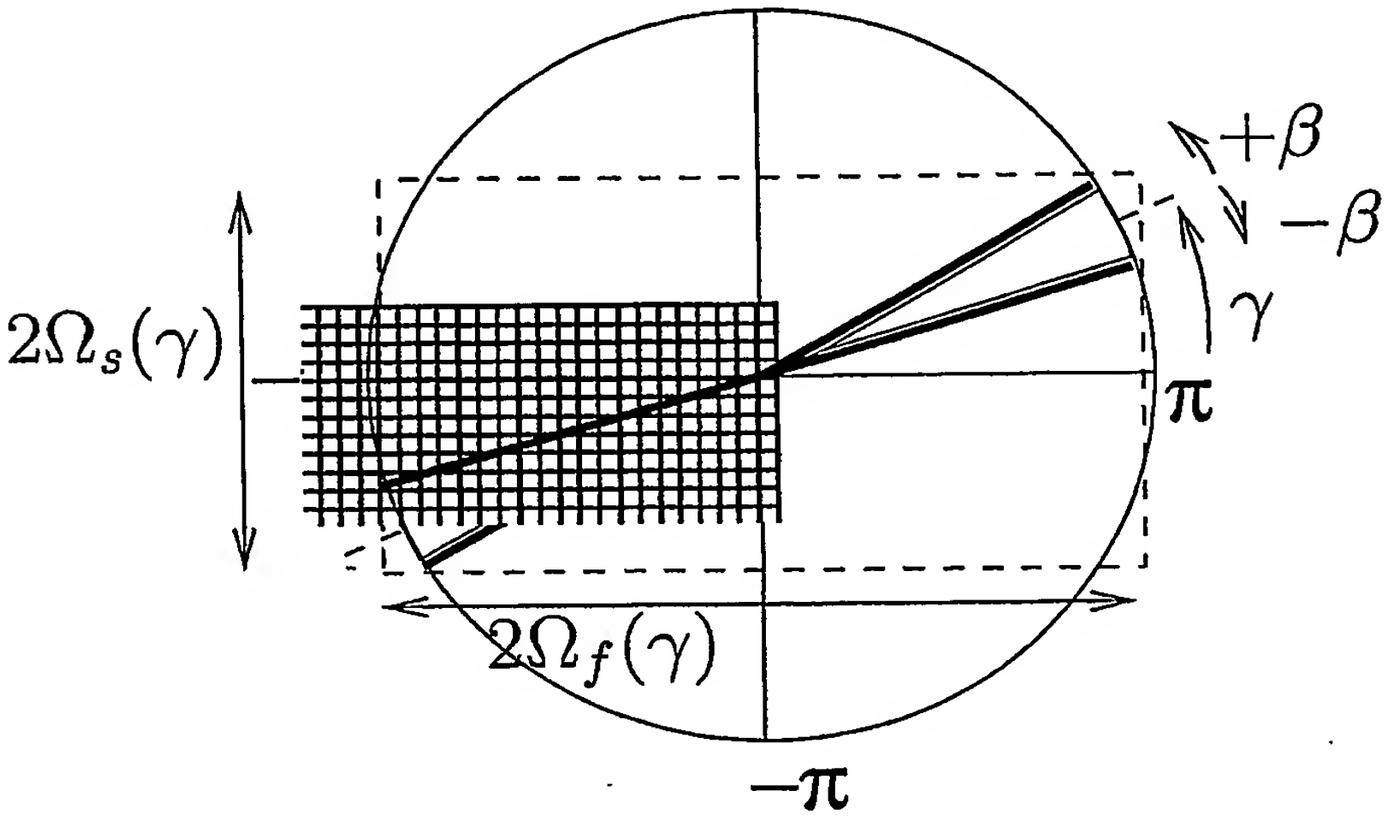

$+\beta$
$-\beta$
γ
$2\Omega_s(\gamma)$
π
$2\Omega_f(\gamma)$
$-\pi$

FIG. 6

FIG.7A

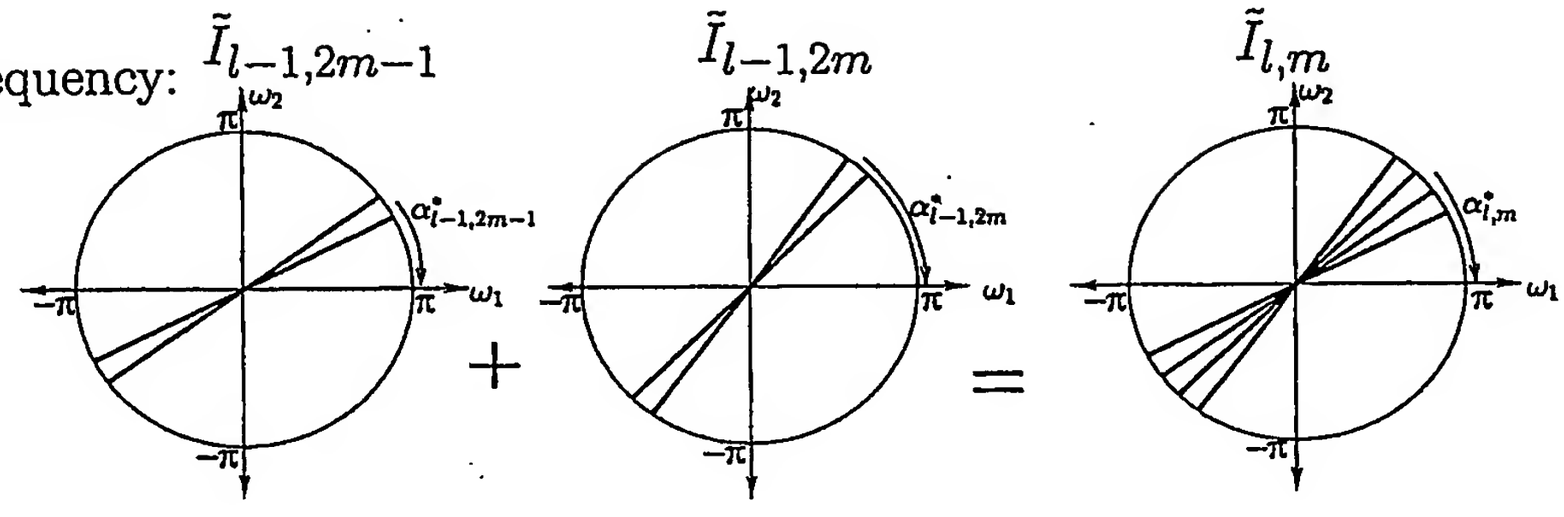
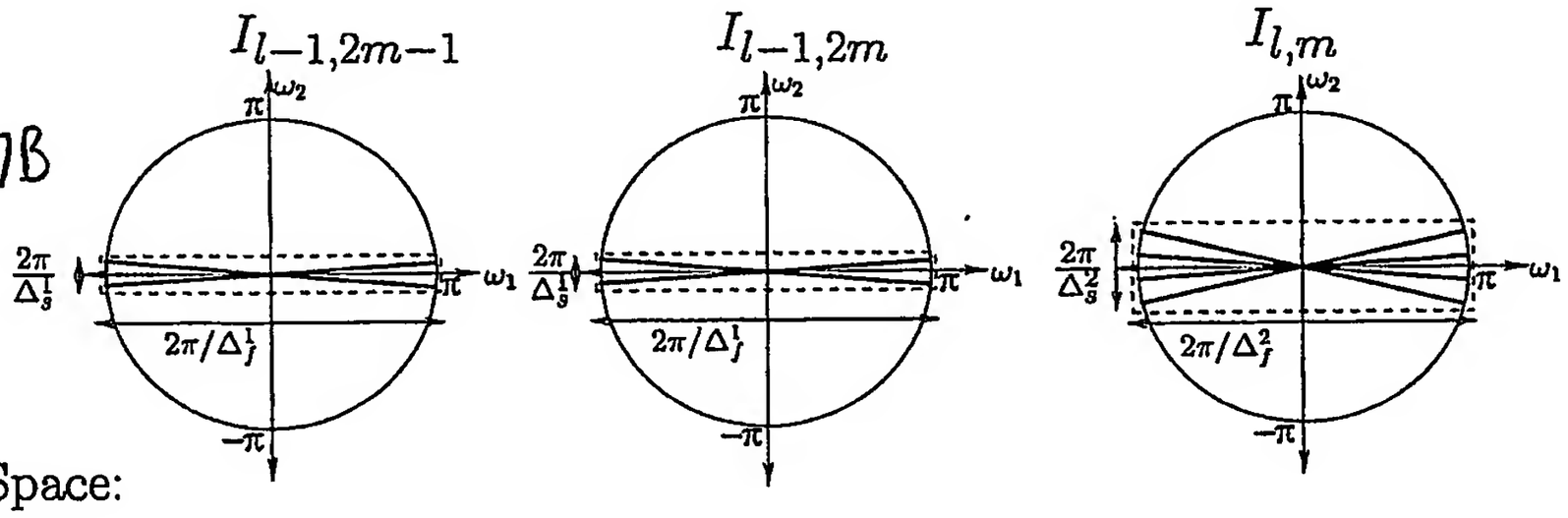
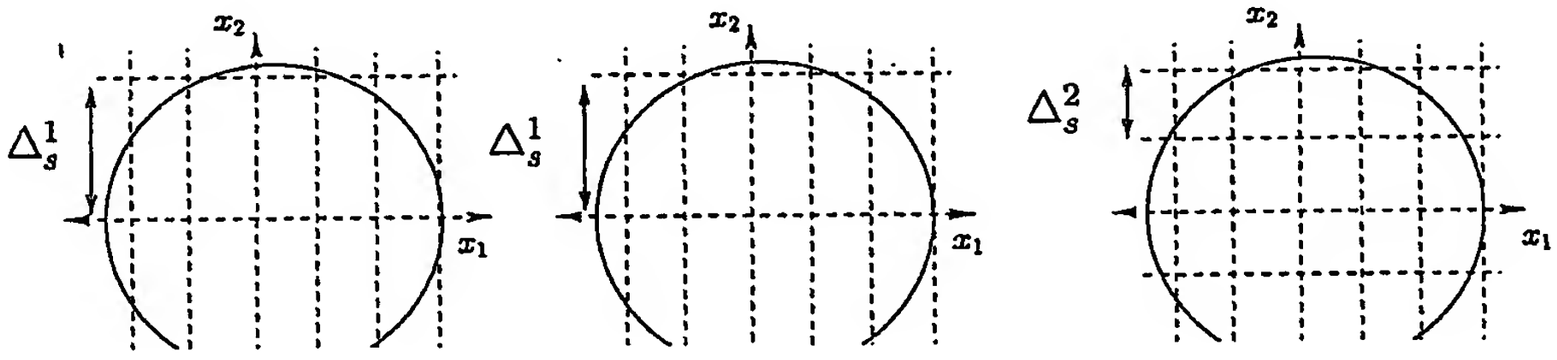


FIG.7B



Space:

FIG.7C



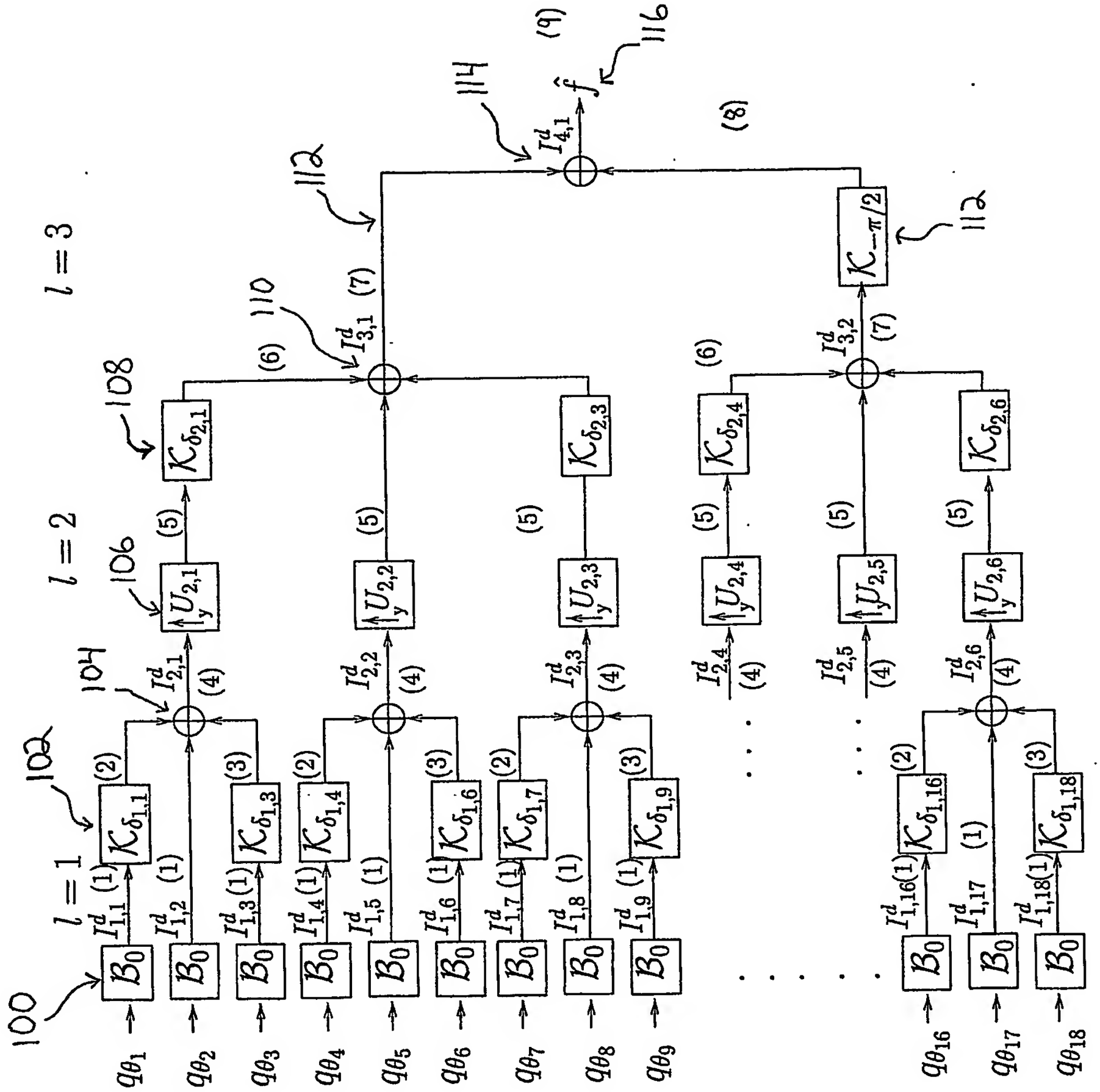

l = 3
l = 2
l = 1
100
102
104
106
108
110
112
114
116
B_0
$K_{\delta_{1,1}}$
$K_{\delta_{1,3}}$
$K_{\delta_{1,4}}$
$K_{\delta_{1,6}}$
$K_{\delta_{1,7}}$
$K_{\delta_{1,9}}$
$K_{\delta_{1,16}}$
$K_{\delta_{1,18}}$
$K_{\delta_{2,1}}$
$K_{\delta_{2,3}}$
$K_{\delta_{2,4}}$
$K_{\delta_{2,6}}$
$K_{-\pi/2}$
$U_{2,1}$
$U_{2,2}$
$U_{2,3}$
$U_{2,4}$
$U_{2,5}$
$U_{2,6}$
$I^d_{1,1}$ $I^d_{1,2}$ $I^d_{1,3}$ $I^d_{1,4}$ $I^d_{1,5}$ $I^d_{1,6}$ $I^d_{1,7}$ $I^d_{1,8}$ $I^d_{1,9}$
$I^d_{1,16}$ $I^d_{1,17}$ $I^d_{1,18}$
$I^d_{2,1}$ $I^d_{2,2}$ $I^d_{2,3}$ $I^d_{2,4}$ $I^d_{2,5}$ $I^d_{2,6}$
$I^d_{3,1}$ $I^d_{3,2}$
$I^d_{4,1}$
$\hat{f}$
q_{θ_1} q_{θ_2} q_{θ_3} q_{θ_4} q_{θ_5} q_{θ_6} q_{θ_7} q_{θ_8} q_{θ_9}
$q_{\theta_{16}}$ $q_{\theta_{17}}$ $q_{\theta_{18}}$
(1) (2) (3) (4) (5) (6) (7) (8) (9)

FIG. 8

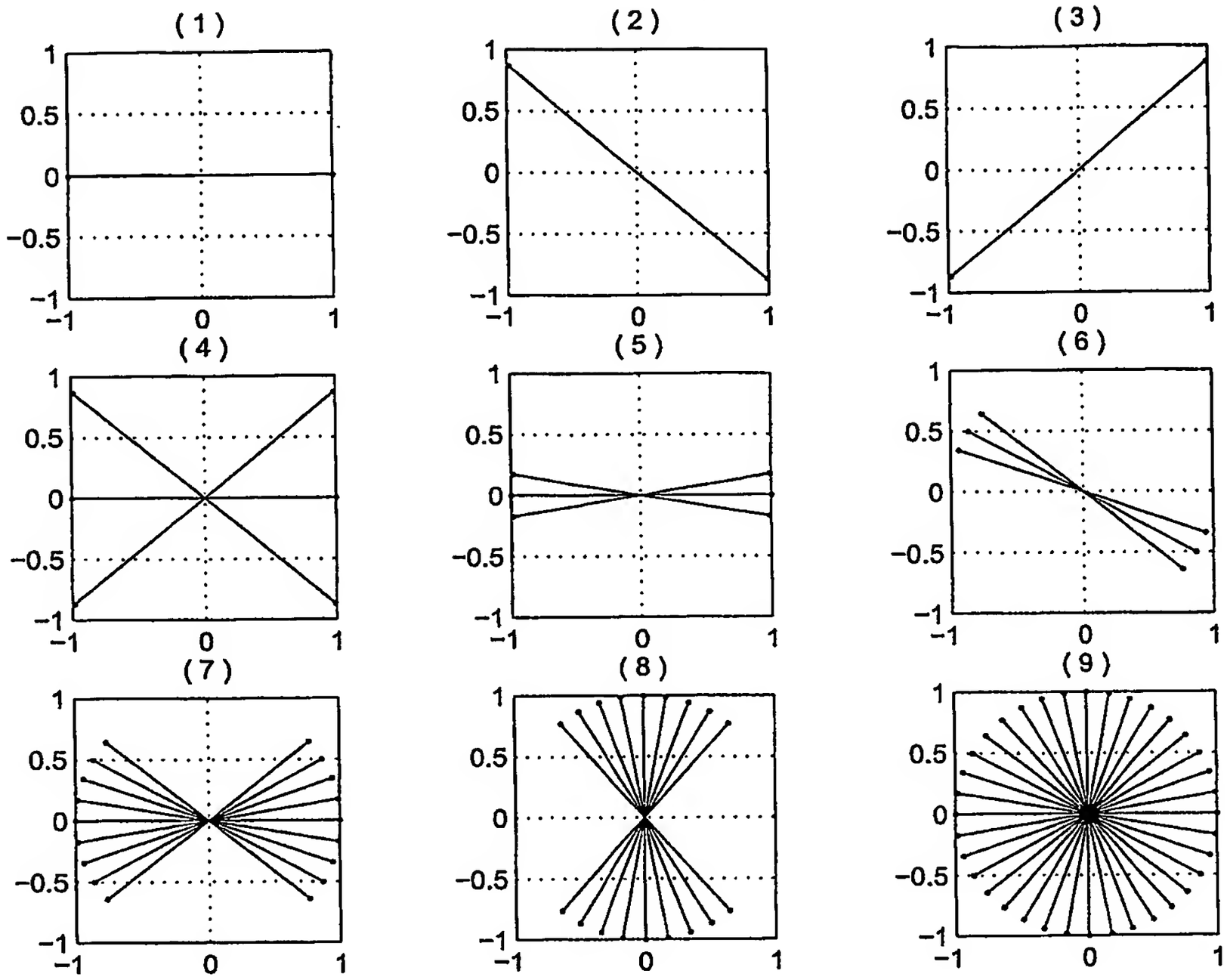


FIG. 9

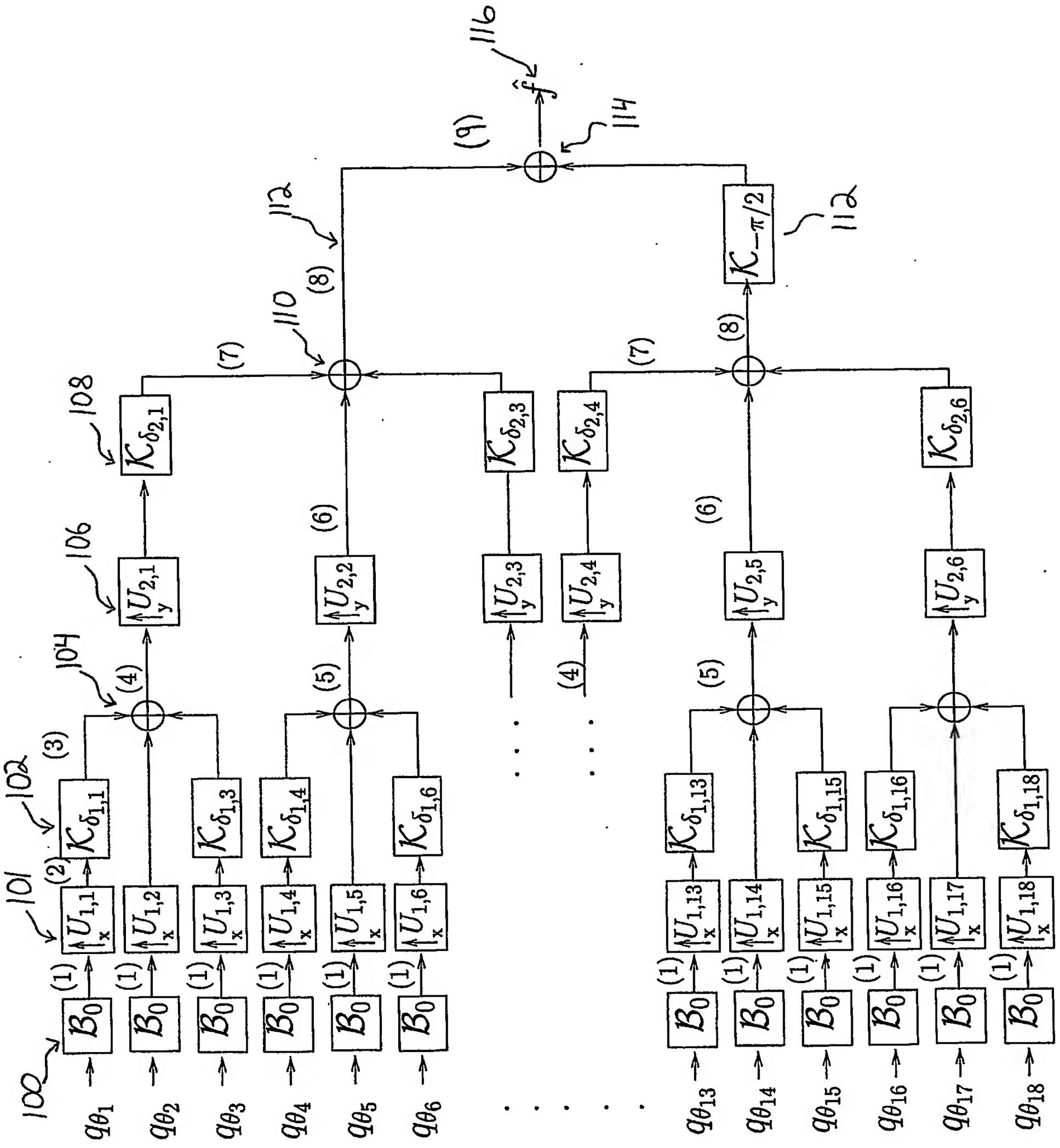
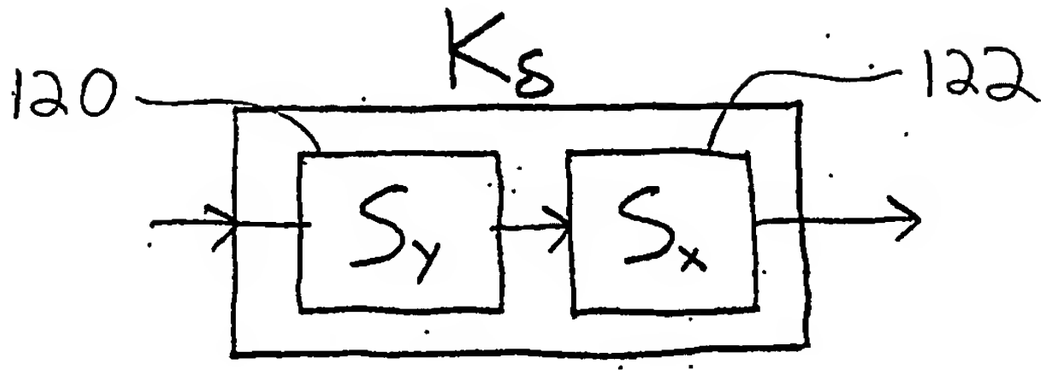

116
$\hat{f}$
(9)
114
112
$K_{-\pi/2}$
112
(8)
110
(7)
108
$K_{\delta_{2,1}}$
106
$U_{y}^{2,1}$
(6)
$K_{\delta_{2,3}}$
$U_{y}^{2,3}$
$K_{\delta_{2,4}}$
$U_{y}^{2,4}$
$K_{\delta_{2,6}}$
$U_{y}^{2,6}$
$U_{y}^{2,2}$
$U_{y}^{2,5}$
104
(4)
(5)
102
(3)
$K_{\delta_{1,1}}$
$K_{\delta_{1,3}}$
$K_{\delta_{1,4}}$
$K_{\delta_{1,6}}$
$K_{\delta_{1,13}}$
$K_{\delta_{1,15}}$
$K_{\delta_{1,16}}$
$K_{\delta_{1,18}}$
101
(2)
$U_{x}^{1,1}$
$U_{x}^{1,2}$
$U_{x}^{1,3}$
$U_{x}^{1,4}$
$U_{x}^{1,5}$
$U_{x}^{1,6}$
$U_{x}^{1,13}$
$U_{x}^{1,14}$
$U_{x}^{1,15}$
$U_{x}^{1,16}$
$U_{x}^{1,17}$
$U_{x}^{1,18}$
(1)
B_0
100
q_{θ_1}
q_{θ_2}
q_{θ_3}
q_{θ_4}
q_{θ_5}
q_{θ_6}
$q_{\theta_{13}}$
$q_{\theta_{14}}$
$q_{\theta_{15}}$
$q_{\theta_{16}}$
$q_{\theta_{17}}$
$q_{\theta_{18}}$

FIG. 10A

FIG. 10B



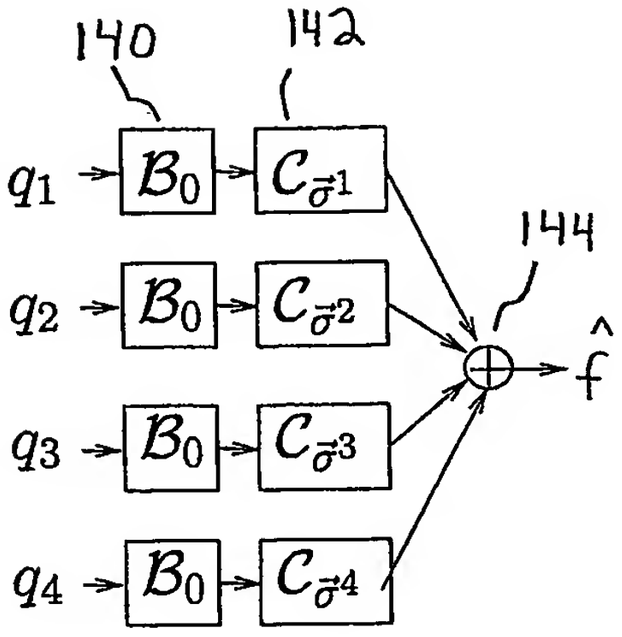


FIG. 11A

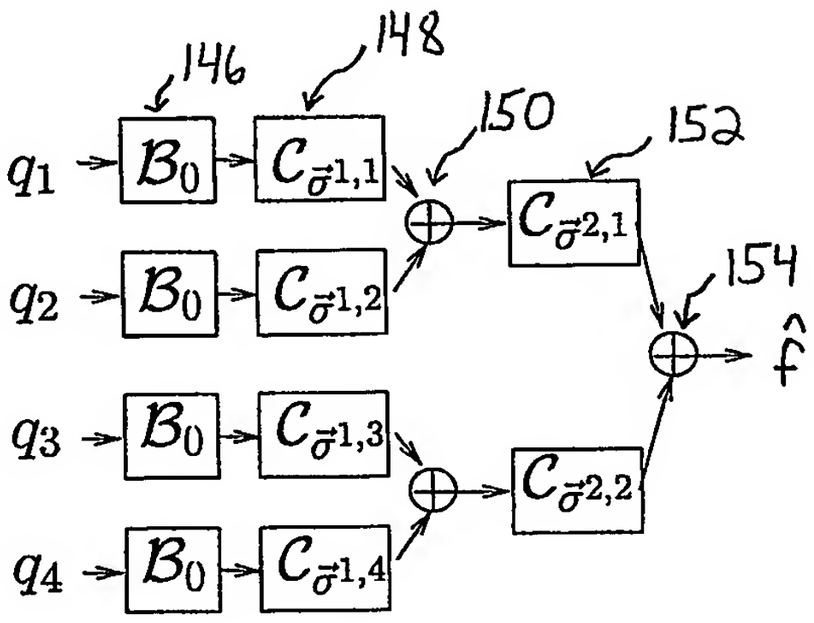


FIG. 11B

FIG. 12A

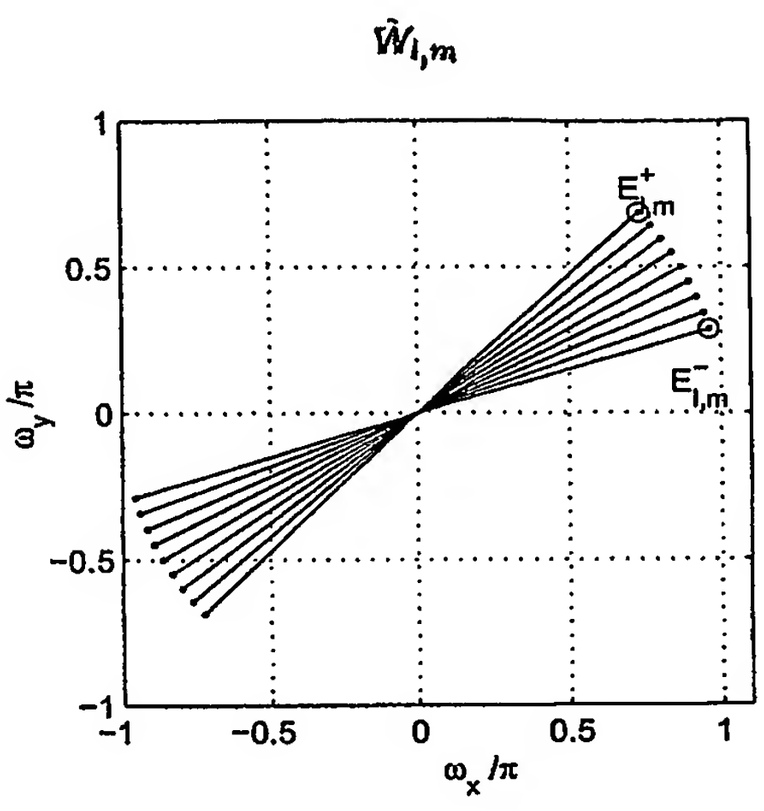
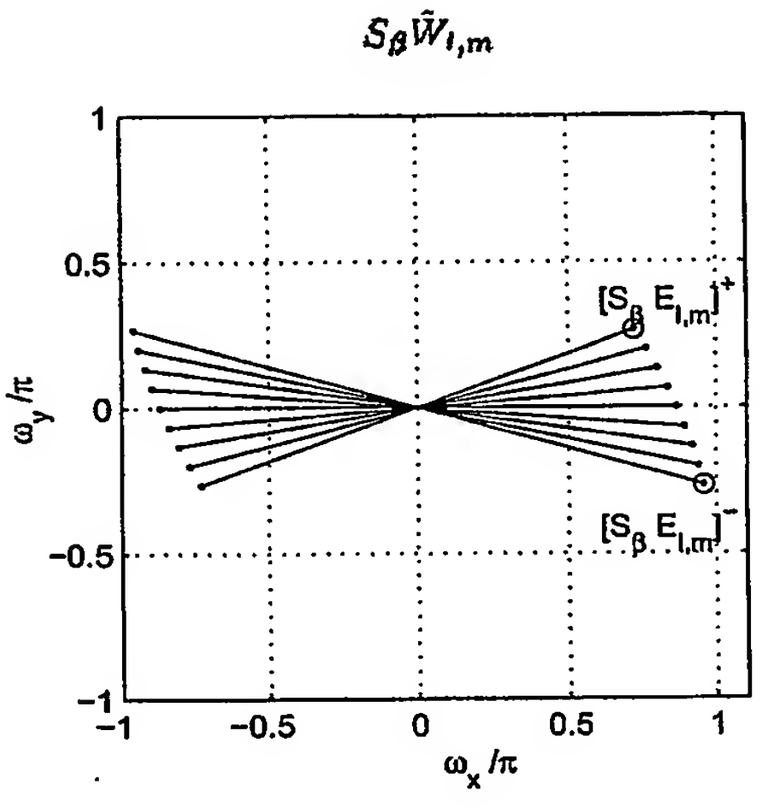


FIG. 12B



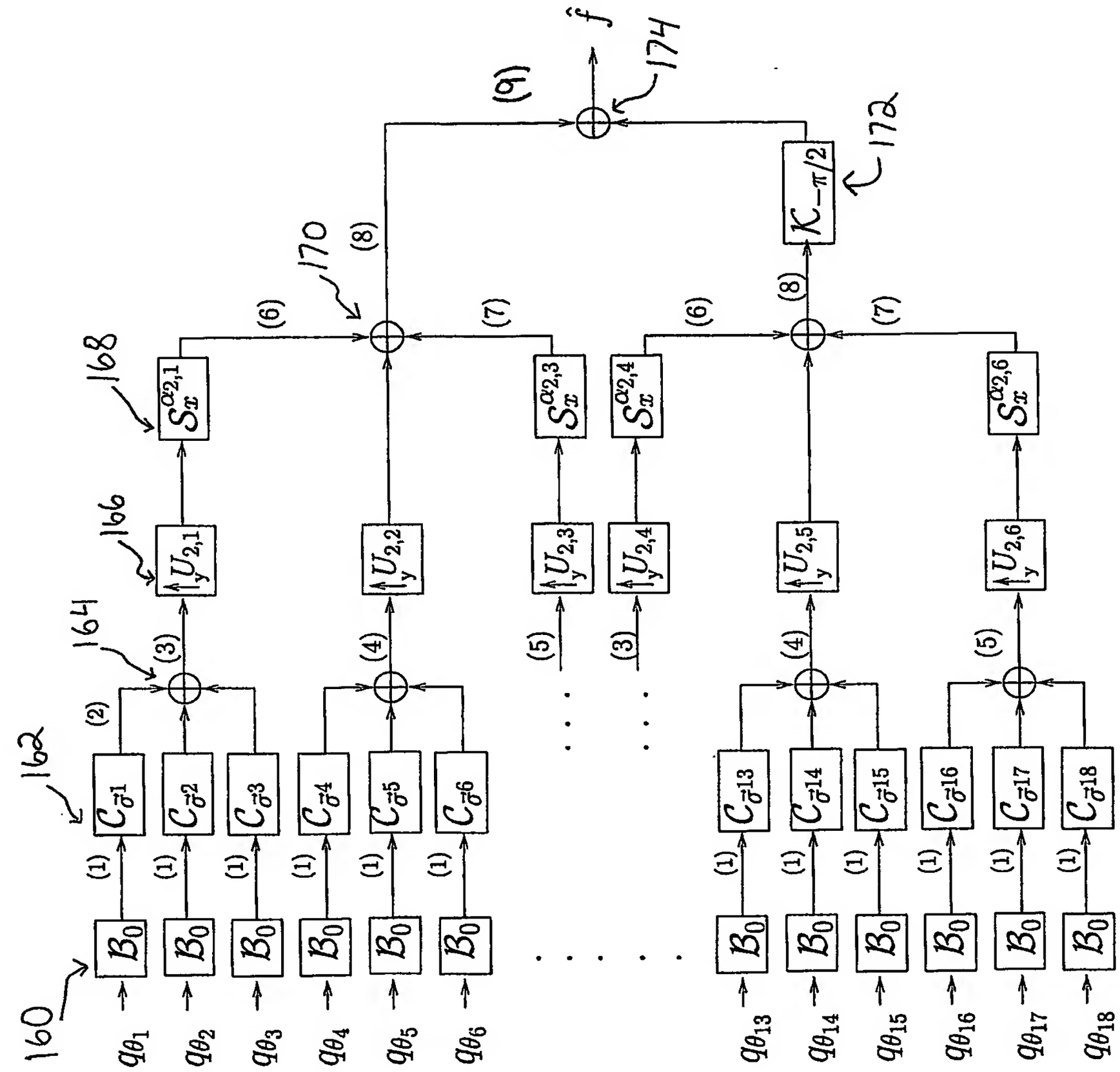

160
170
172
174
162
164
166
168
(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
B_0
$C_{\vec{\sigma}^1}$
$C_{\vec{\sigma}^2}$
$C_{\vec{\sigma}^3}$
$C_{\vec{\sigma}^4}$
$C_{\vec{\sigma}^5}$
$C_{\vec{\sigma}^6}$
$C_{\vec{\sigma}^{13}}$
$C_{\vec{\sigma}^{14}}$
$C_{\vec{\sigma}^{15}}$
$C_{\vec{\sigma}^{16}}$
$C_{\vec{\sigma}^{17}}$
$C_{\vec{\sigma}^{18}}$
$U_{2,1}$
$U_{2,2}$
$U_{2,3}$
$U_{2,4}$
$U_{2,5}$
$U_{2,6}$
$S_x^{\alpha_{2,1}}$
$S_x^{\alpha_{2,3}}$
$S_x^{\alpha_{2,4}}$
$S_x^{\alpha_{2,6}}$
$K_{-\pi/2}$
f
q_{θ_1}
q_{θ_2}
q_{θ_3}
q_{θ_4}
q_{θ_5}
q_{θ_6}
$q_{\theta_{13}}$
$q_{\theta_{14}}$
$q_{\theta_{15}}$
$q_{\theta_{16}}$
$q_{\theta_{17}}$
$q_{\theta_{18}}$

FIG. 13

FINDALPHAS($E_{L+1,1}, E_{L+1,2}$):
for $l \leftarrow L$ downto 2
for $m \leftarrow 1$ to $6 \cdot 3^{L-l}$
for $i \in \{0, 2\}$

$$\alpha^*_{l,3m-i} = -\frac{(E^i_{l+1,m})^+_y + (E^i_{l+1,m})^-_y}{(E^i_{l+1,m})^+_x + (E^i_{l+1,m})^-_x}$$

$$E_{l,3m-i} = \mathcal{S}(-\alpha_{l,3m-i}) E^i_{l,3m-i}$$

FIG. 14

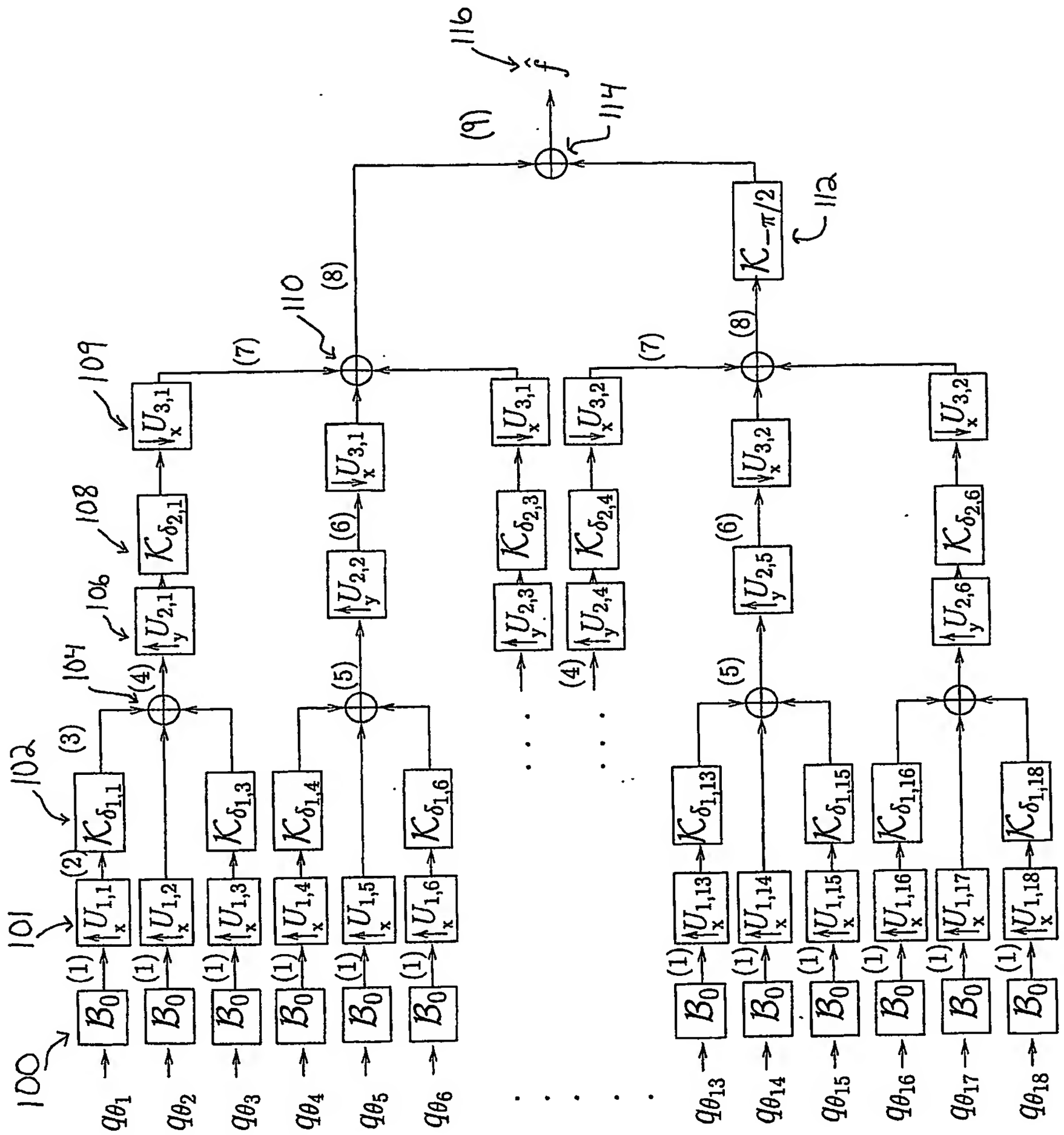

100
101
102
104
106
108
109
110
112
114
116
(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
B_0
U_x
U_y
K_{δ}
$K_{-\pi/2}$
q_{θ_1}
q_{θ_2}
q_{θ_3}
q_{θ_4}
q_{θ_5}
q_{θ_6}
$q_{\theta_{13}}$
$q_{\theta_{14}}$
$q_{\theta_{15}}$
$q_{\theta_{16}}$
$q_{\theta_{17}}$
$q_{\theta_{18}}$

FIG. 15

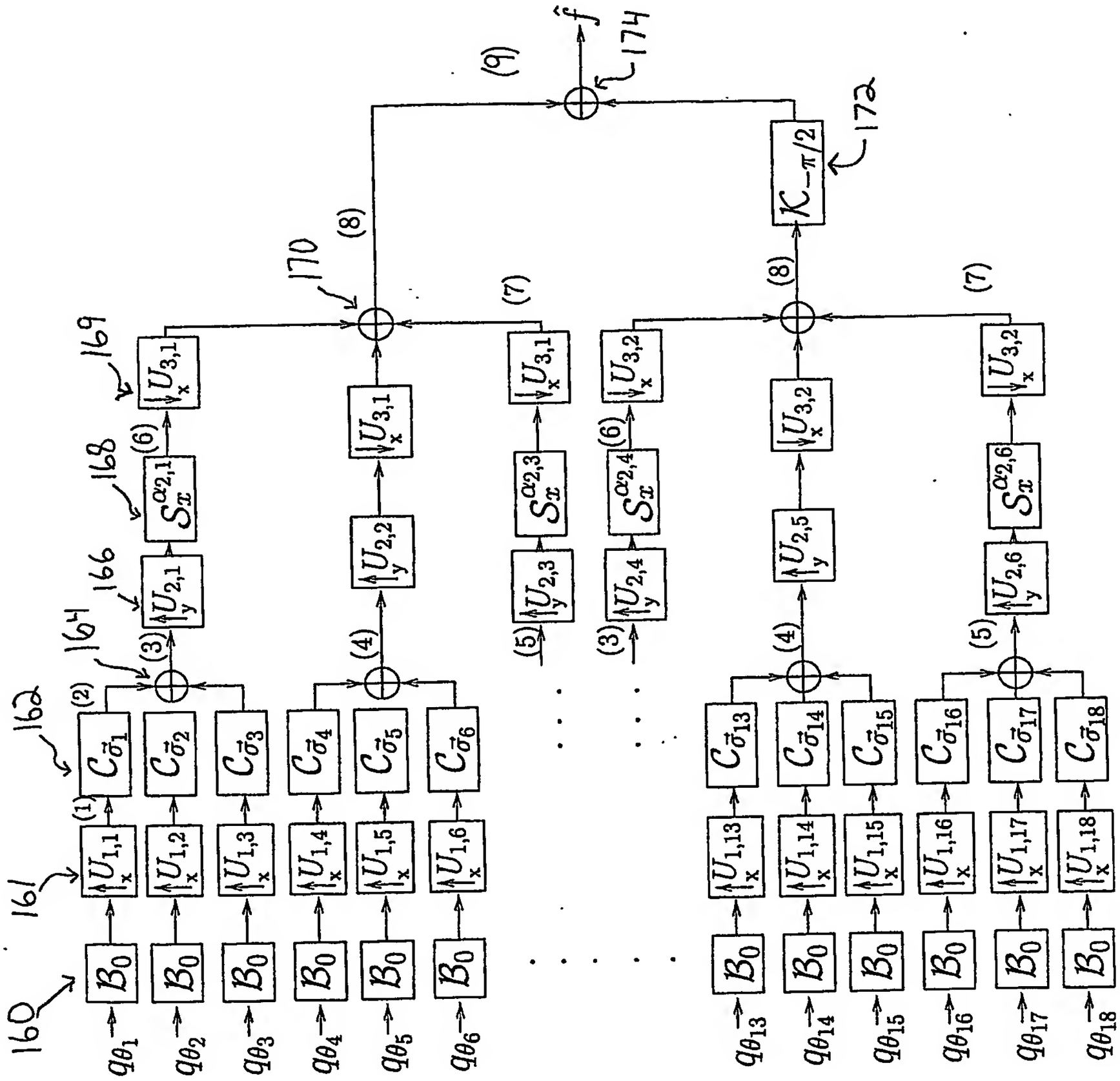
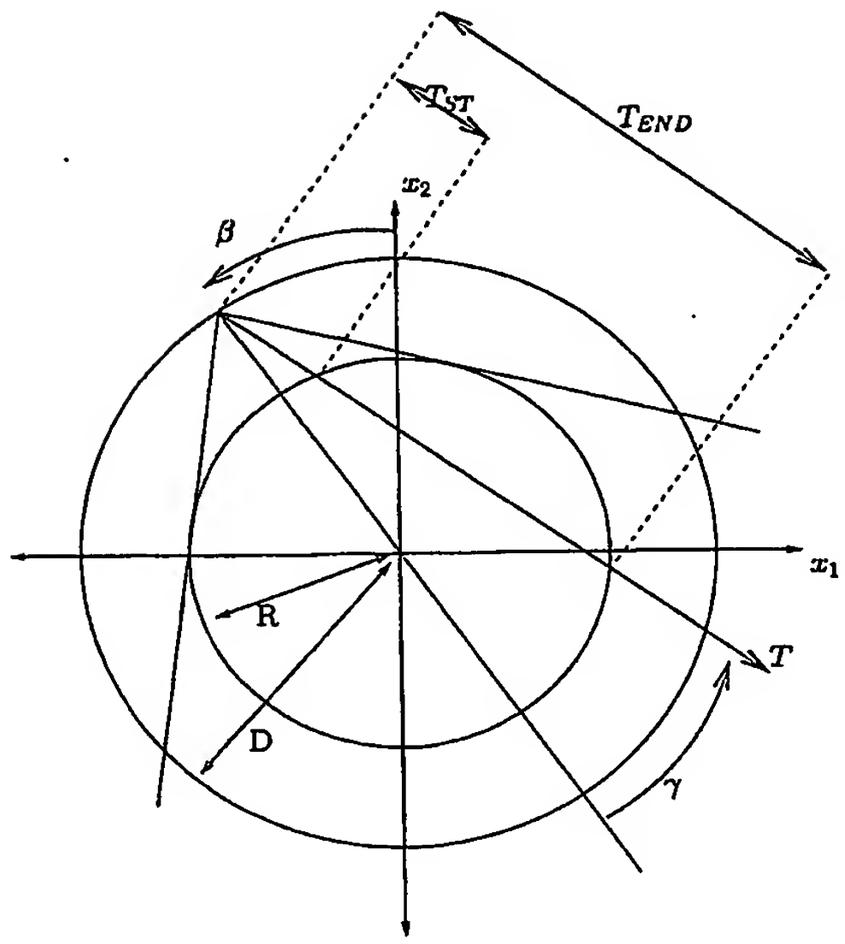

160
161
162
164
166
168
169
170
172
174
(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
B_0
$U_{1,1}$
$U_{1,2}$
$U_{1,3}$
$U_{1,4}$
$U_{1,5}$
$U_{1,6}$
$U_{1,13}$
$U_{1,14}$
$U_{1,15}$
$U_{1,16}$
$U_{1,17}$
$U_{1,18}$
$C_{\vec{\sigma}_1}$
$C_{\vec{\sigma}_2}$
$C_{\vec{\sigma}_3}$
$C_{\vec{\sigma}_4}$
$C_{\vec{\sigma}_5}$
$C_{\vec{\sigma}_6}$
$C_{\vec{\sigma}_{13}}$
$C_{\vec{\sigma}_{14}}$
$C_{\vec{\sigma}_{15}}$
$C_{\vec{\sigma}_{16}}$
$C_{\vec{\sigma}_{17}}$
$C_{\vec{\sigma}_{18}}$
$U_{2,1}$
$U_{2,2}$
$U_{2,3}$
$U_{2,4}$
$U_{2,5}$
$U_{2,6}$
$U_{3,1}$
$U_{3,2}$
$S_x^{\alpha_{2,1}}$
$S_x^{\alpha_{2,3}}$
$S_x^{\alpha_{2,4}}$
$S_x^{\alpha_{2,6}}$
$K_{-\pi/2}$
$\hat{f}$
q_{θ_1}
q_{θ_2}
q_{θ_3}
q_{θ_4}
q_{θ_5}
q_{θ_6}
$q_{\theta_{13}}$
$q_{\theta_{14}}$
$q_{\theta_{15}}$
$q_{\theta_{16}}$
$q_{\theta_{17}}$
$q_{\theta_{18}}$

FIG. 16

FIG. 17



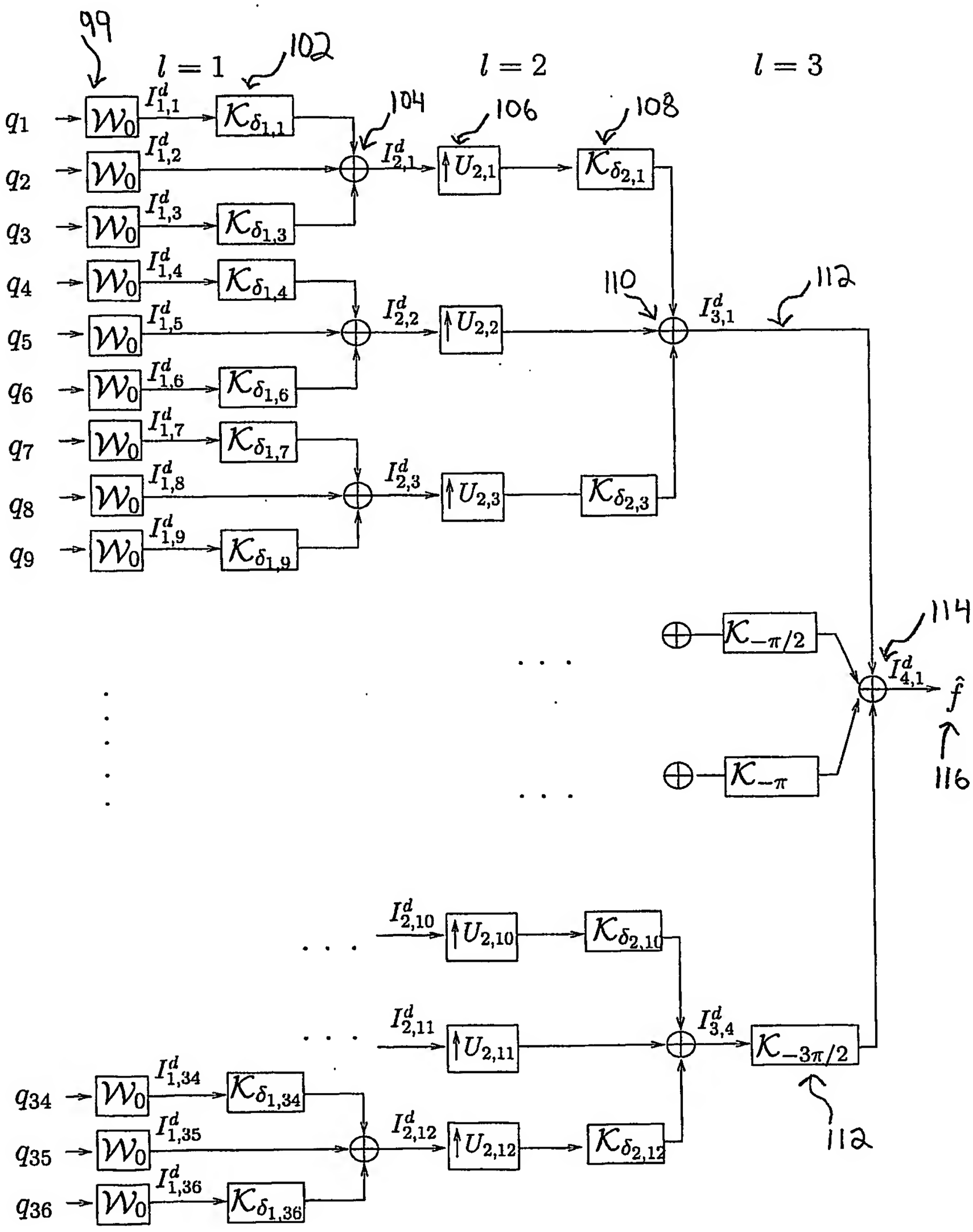

99
l = 1
102
l = 2
l = 3
104
106
108
110
112
114
116
q_1
q_2
q_3
q_4
q_5
q_6
q_7
q_8
q_9
q_{34}
q_{35}
q_{36}
$\mathcal{W}_0$
$I^d_{1,1}$
$I^d_{1,2}$
$I^d_{1,3}$
$I^d_{1,4}$
$I^d_{1,5}$
$I^d_{1,6}$
$I^d_{1,7}$
$I^d_{1,8}$
$I^d_{1,9}$
$I^d_{1,34}$
$I^d_{1,35}$
$I^d_{1,36}$
$\mathcal{K}_{\delta_{1,1}}$
$\mathcal{K}_{\delta_{1,3}}$
$\mathcal{K}_{\delta_{1,4}}$
$\mathcal{K}_{\delta_{1,6}}$
$\mathcal{K}_{\delta_{1,7}}$
$\mathcal{K}_{\delta_{1,9}}$
$\mathcal{K}_{\delta_{1,34}}$
$\mathcal{K}_{\delta_{1,36}}$
$I^d_{2,1}$
$I^d_{2,2}$
$I^d_{2,3}$
$I^d_{2,10}$
$I^d_{2,11}$
$I^d_{2,12}$
$\uparrow U_{2,1}$
$\uparrow U_{2,2}$
$\uparrow U_{2,3}$
$\uparrow U_{2,10}$
$\uparrow U_{2,11}$
$\uparrow U_{2,12}$
$\mathcal{K}_{\delta_{2,1}}$
$\mathcal{K}_{\delta_{2,3}}$
$\mathcal{K}_{\delta_{2,10}}$
$\mathcal{K}_{\delta_{2,12}}$
$I^d_{3,1}$
$I^d_{3,4}$
$\mathcal{K}_{-\pi/2}$
$\mathcal{K}_{-\pi}$
$\mathcal{K}_{-3\pi/2}$
$I^d_{4,1}$
$\hat{f}$

FIG. 18

FIG. 19

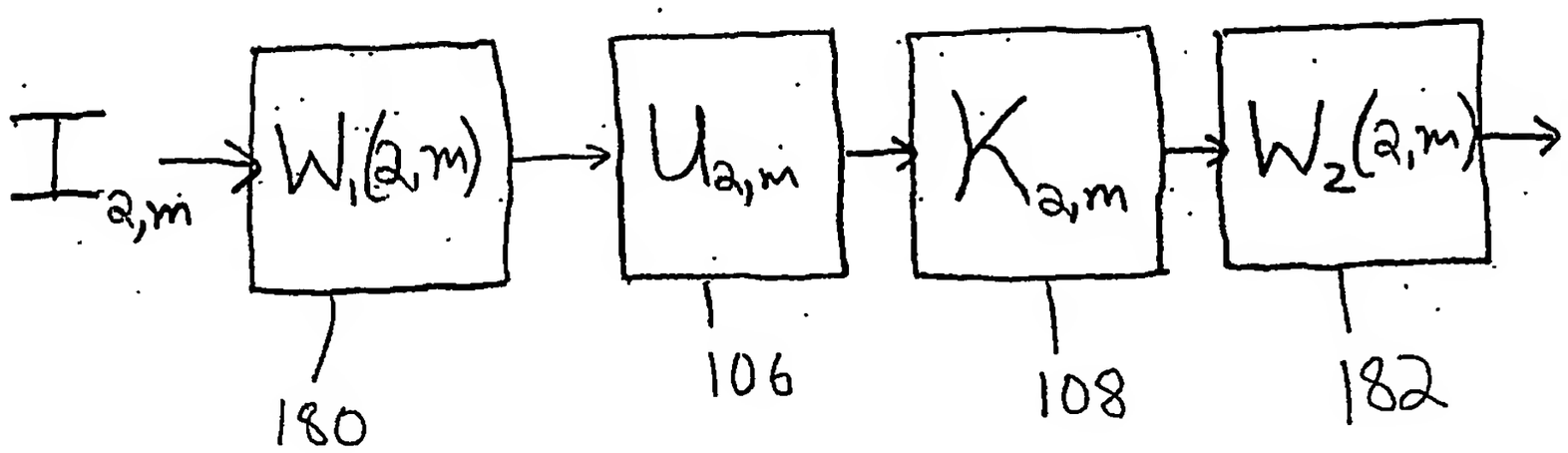


FIG. 20A

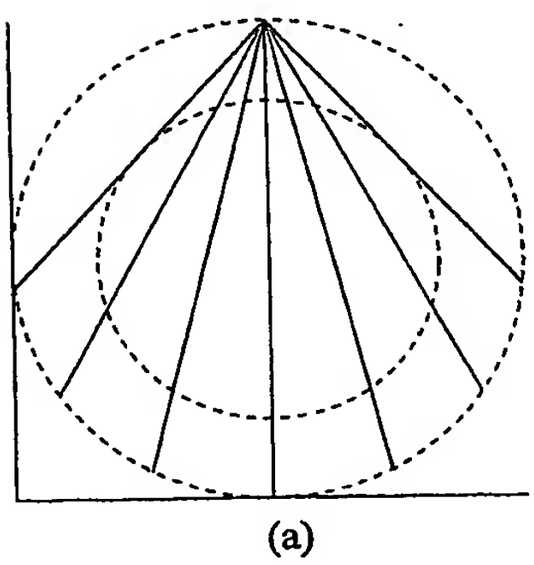


FIG. 20B

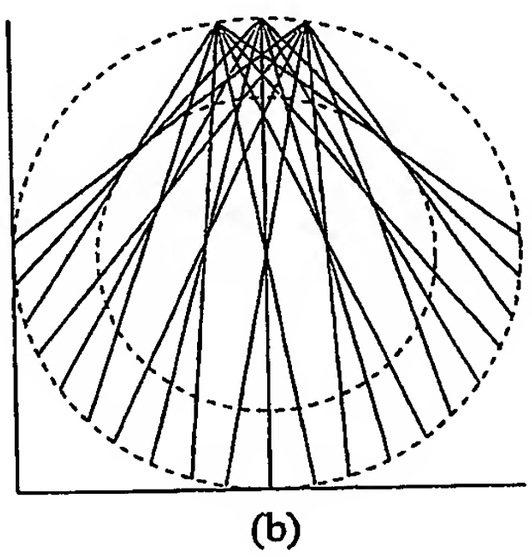


FIG. 20C

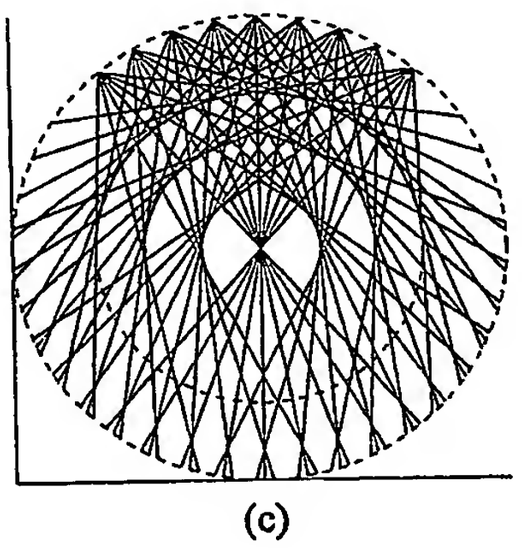


FIG. 21A

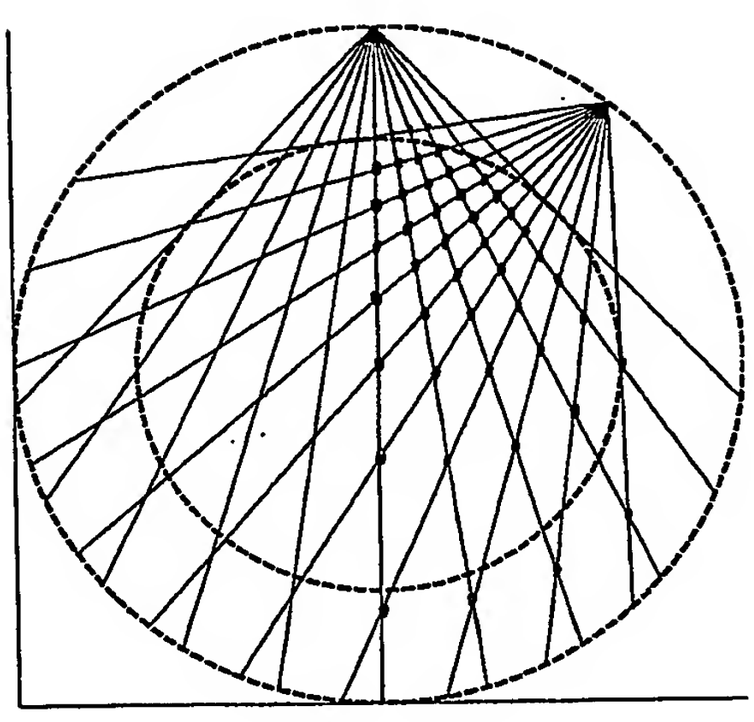


FIG. 21B

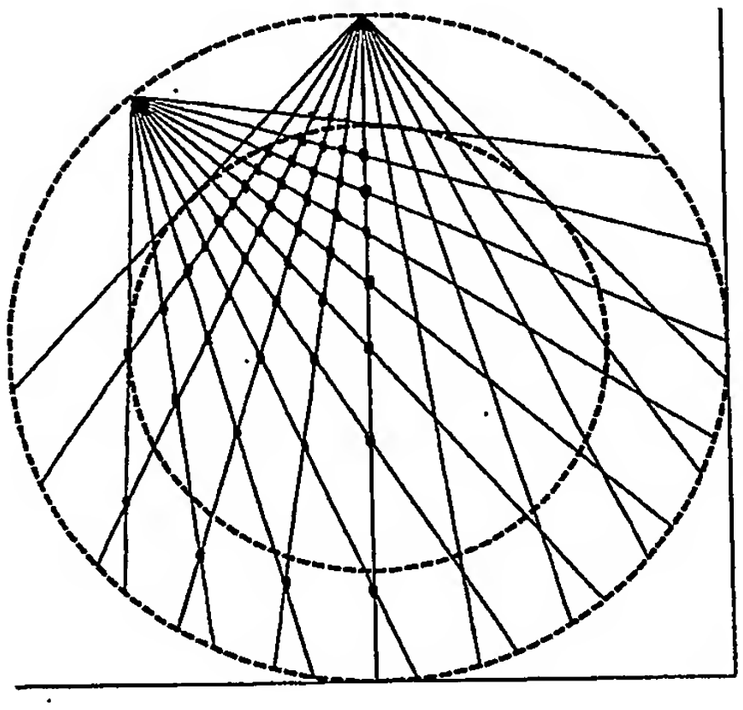
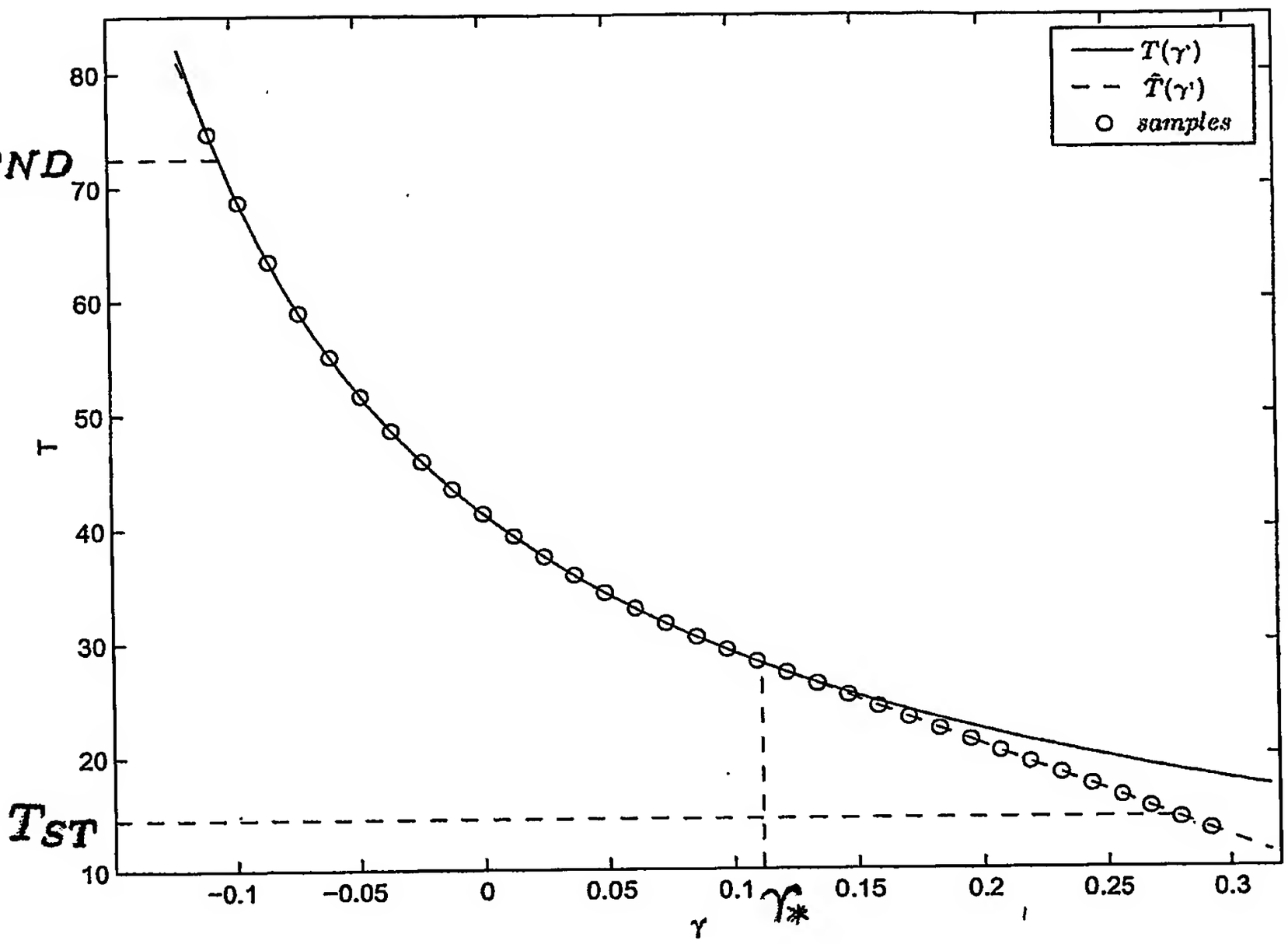


FIG. 22



$T_{\beta,\beta',\gamma_r}(\gamma')$ and $\tilde{T}_{\beta,\beta',\gamma_r}(\gamma')$

FIG. 23A

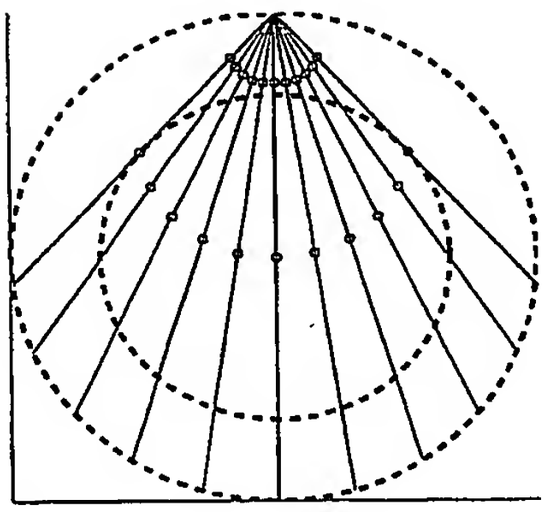
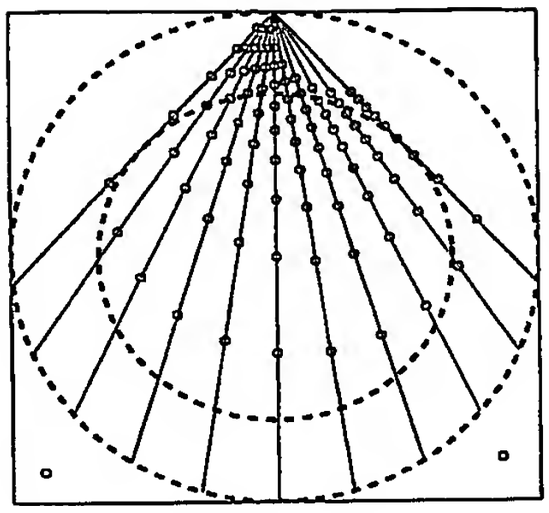


FIG. 23B



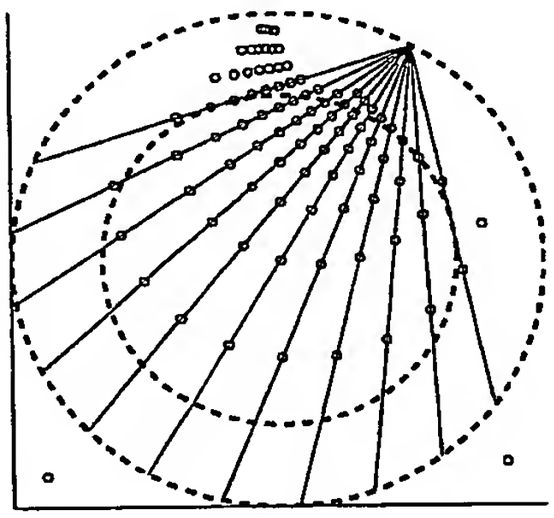


FIG. 23C

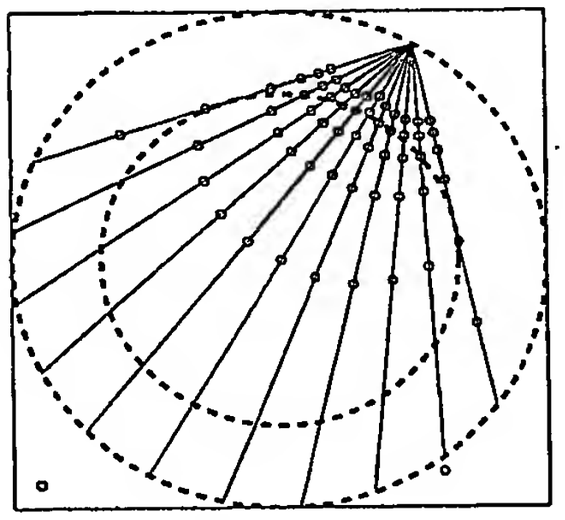


FIG. 23D

FIG. 24

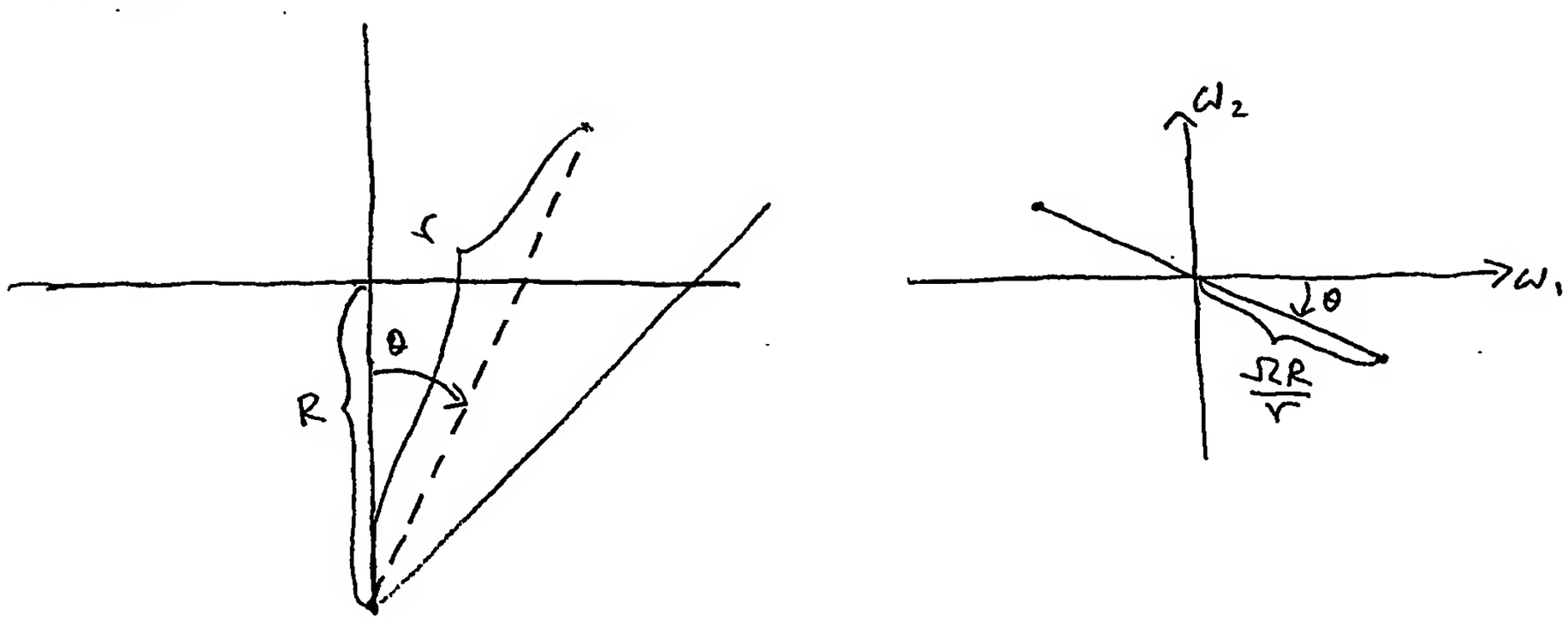


FIG. 25

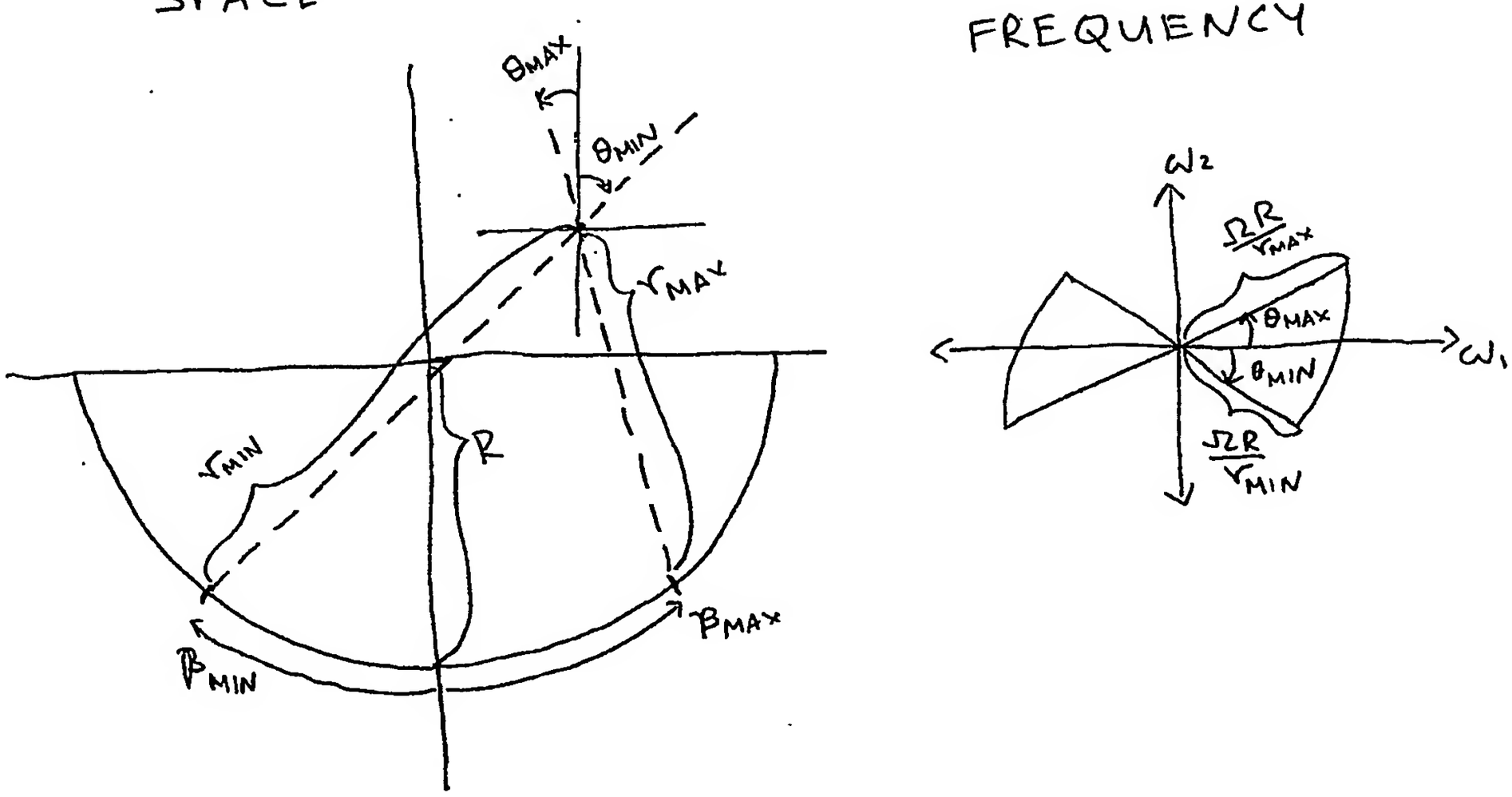

SPACE
FREQUENCY
θMAX
θMIN
rMAX
rMIN
R
βMAX
βMIN
ω2
ω1
ΩR/rMAX
ΩR/rMIN
θMAX
θMIN

FIG. 26A

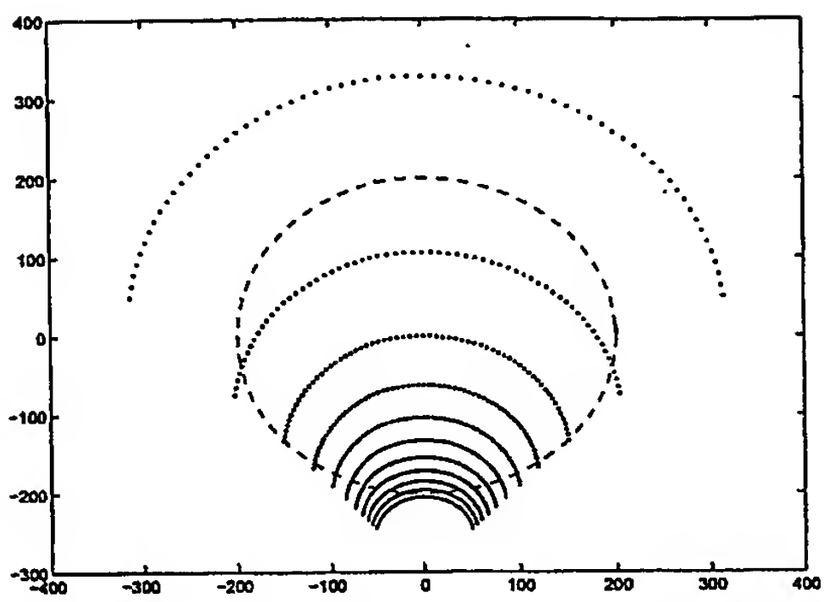


FIG. 26B

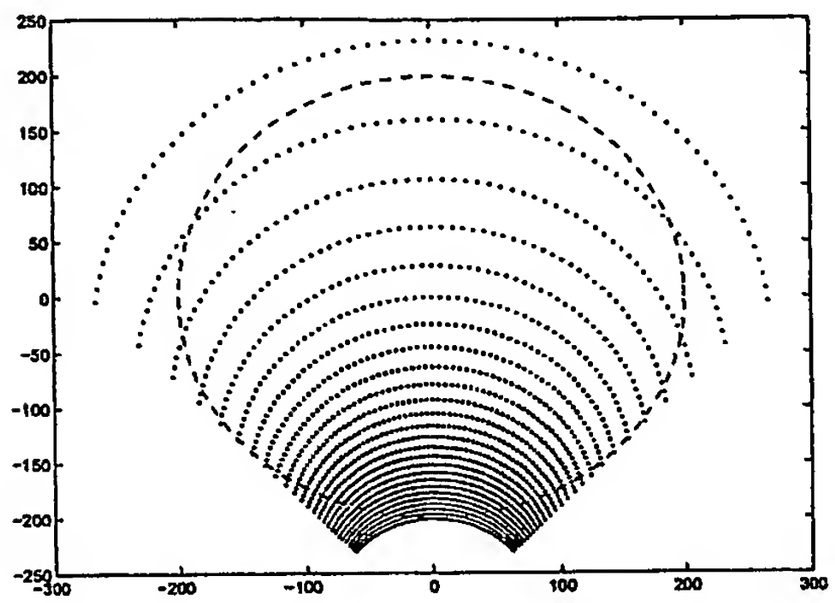
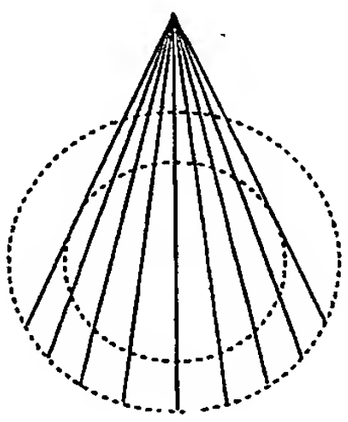


FIG. 27A



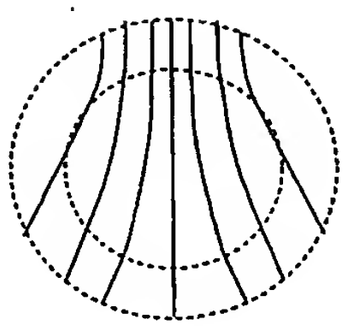
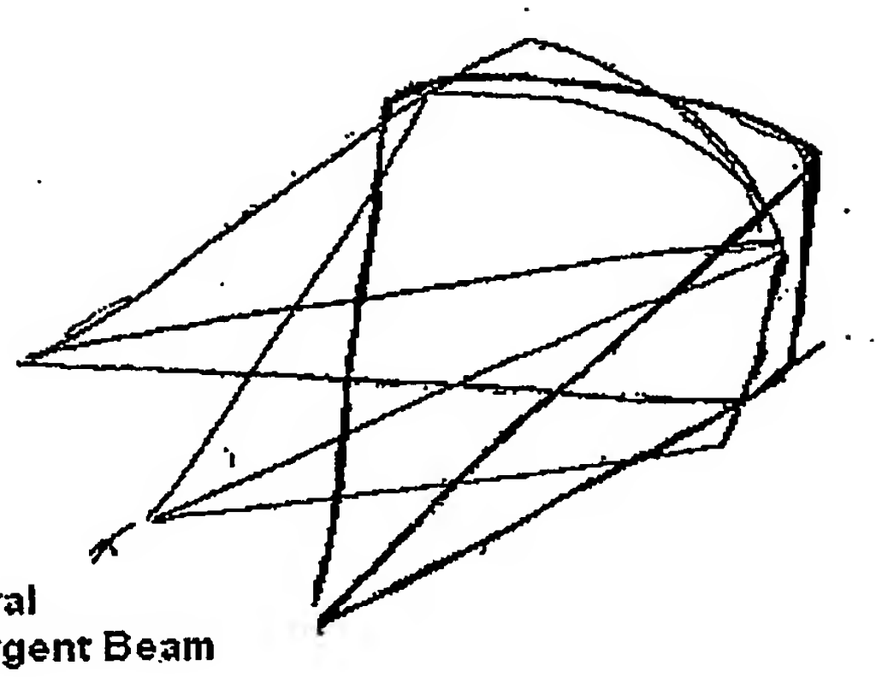
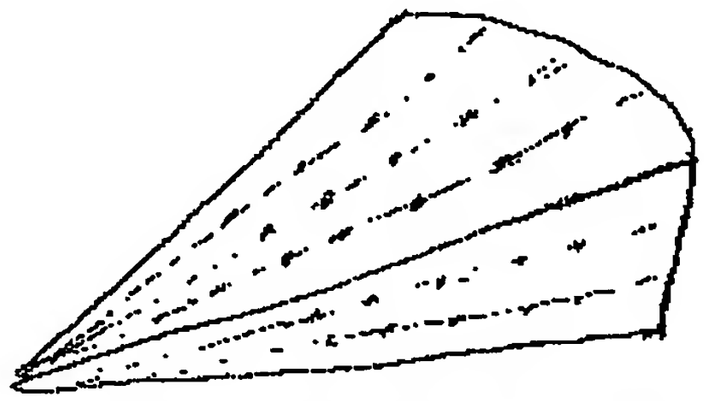


FIG. 27B



Central
Divergent Beam



Sampling on the Central Divergent
Beam

FIG. 28

FIG. 29A

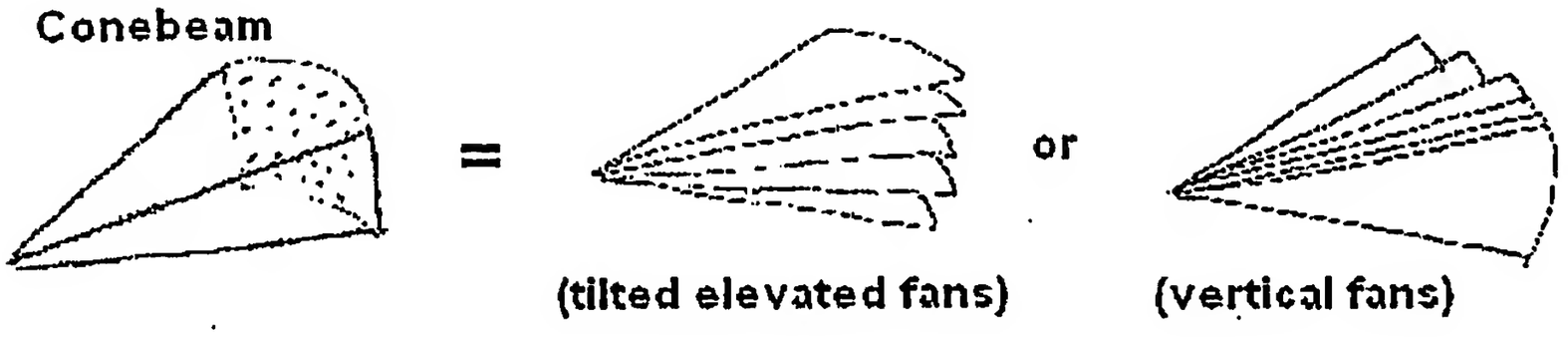
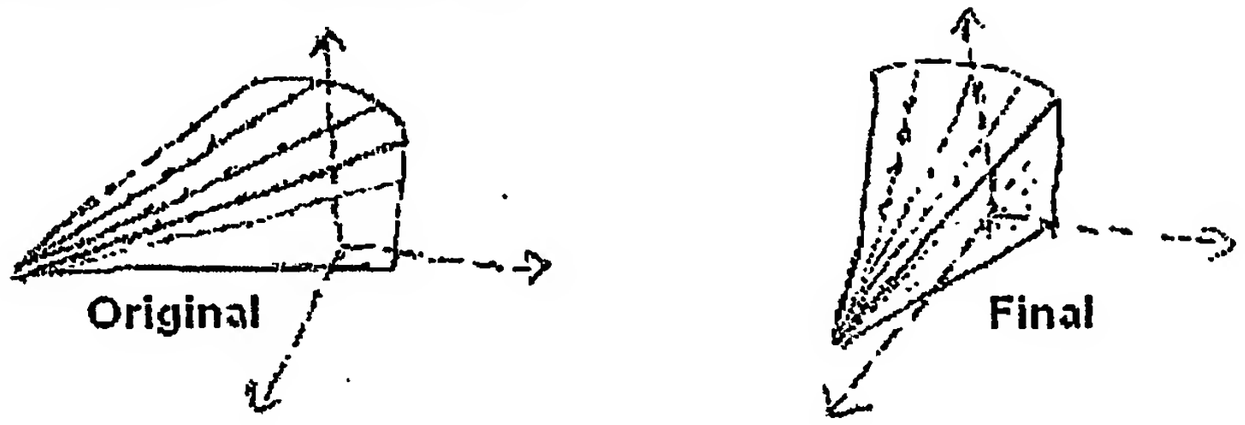
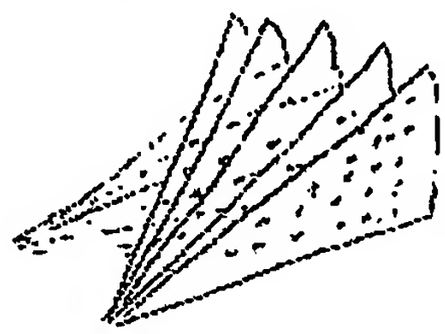


FIG. 29B **Separable Resampling:**



(1)



Resample onto the points of intersection of the original rays with the vertical fans of the final beam

(2) **Resample on individual vertical fans (as in the fanbeam case)**

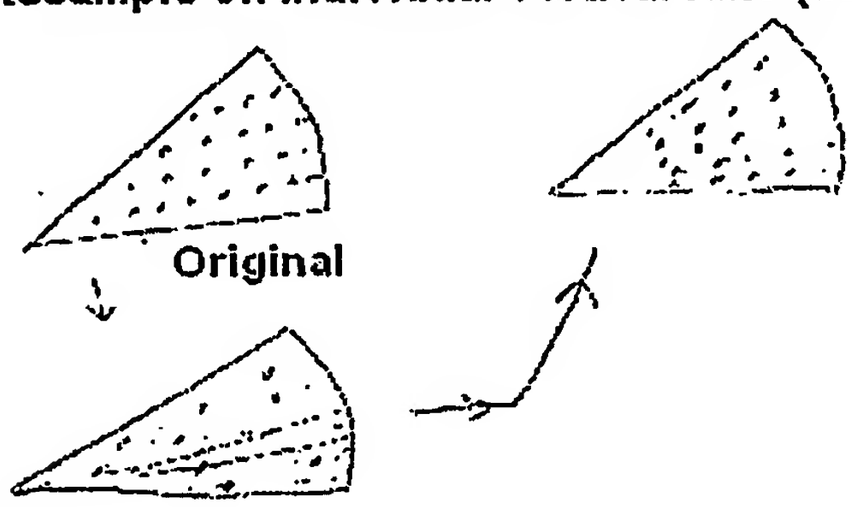
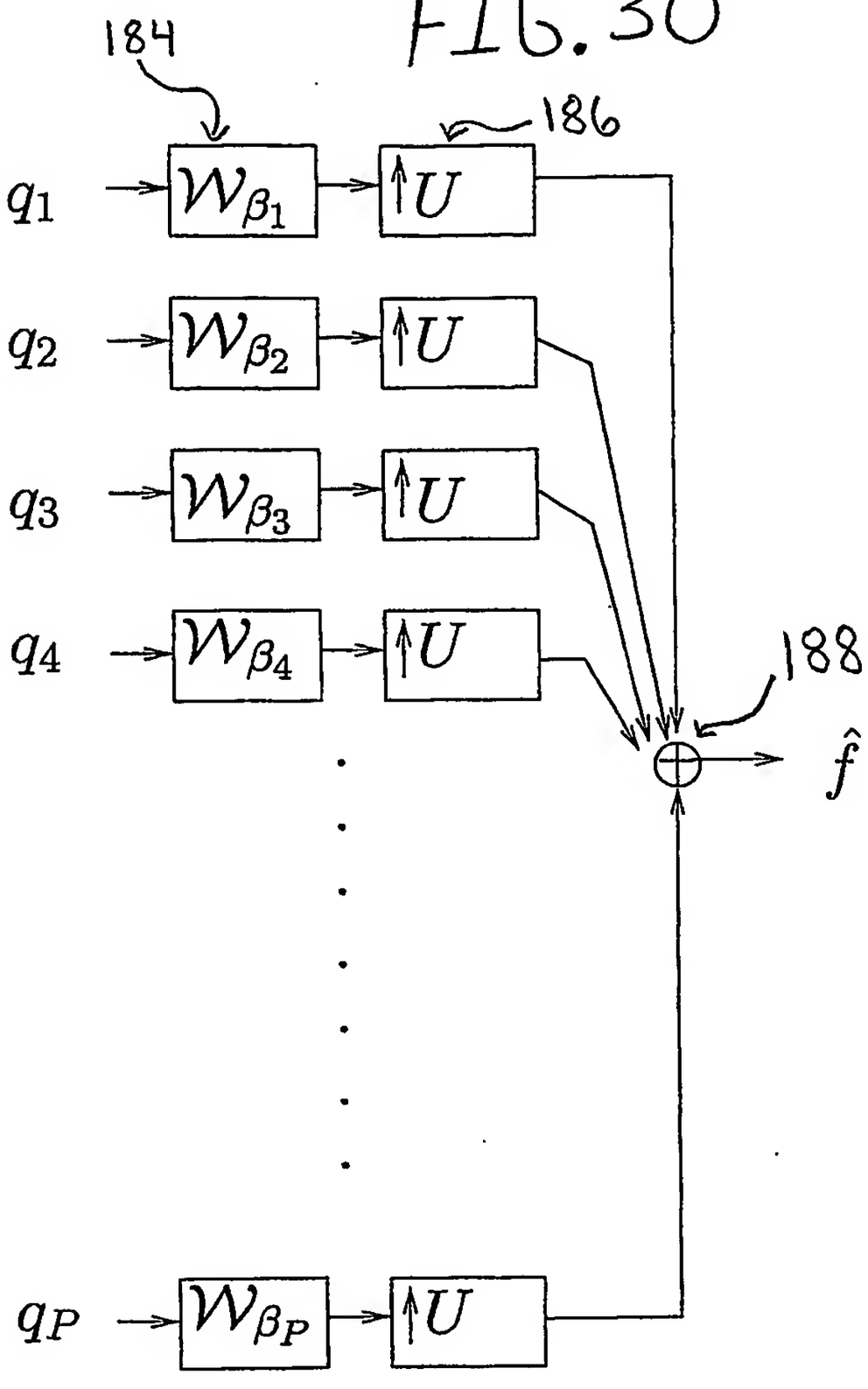


FIG. 30


184
186
q_1
$\mathcal{W}_{\beta_1}$
$\uparrow U$
q_2
$\mathcal{W}_{\beta_2}$
$\uparrow U$
q_3
$\mathcal{W}_{\beta_3}$
$\uparrow U$
q_4
$\mathcal{W}_{\beta_4}$
$\uparrow U$
188
$\hat{f}$
q_P
$\mathcal{W}_{\beta_P}$
$\uparrow U$

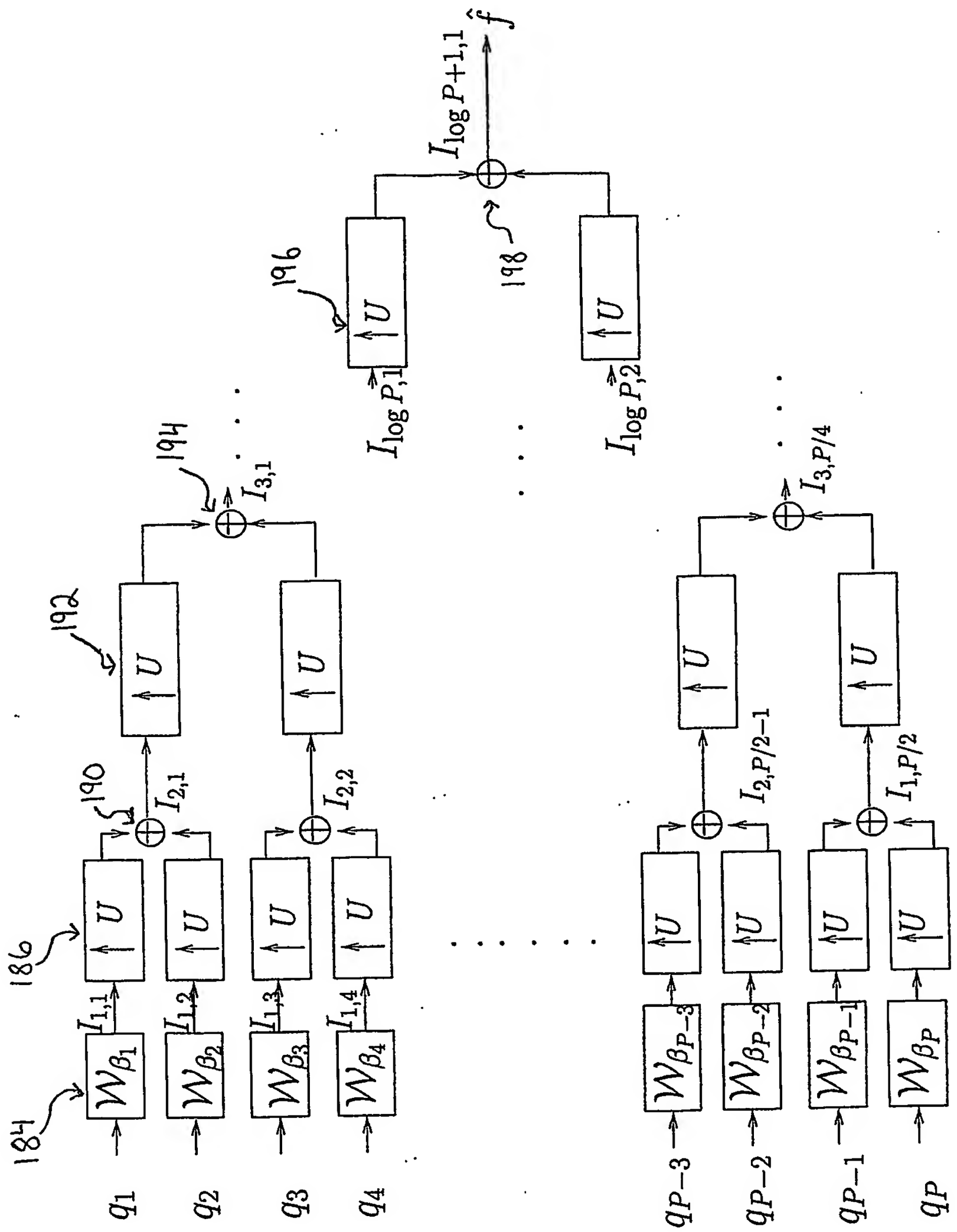

$I_{\log P+1,1}$
$\hat{f}$
196
198
U
$P_{,1}$
$P_{,2}$
194
$I_{3,1}$
192
190
$I_{2,1}$
$I_{2,2}$
186
$I_{1,1}$
$I_{1,2}$
$I_{1,3}$
$I_{1,4}$
W_{β_1}
W_{β_2}
W_{β_3}
W_{β_4}
184
q_1
q_2
q_3
q_4
$I_{\log$
$I_{\log$
$I_{3,P/4}$
$I_{2,P/2-1}$
$I_{1,P/2}$
$W_{\beta_{P-3}}$
$W_{\beta_{P-2}}$
$W_{\beta_{P-1}}$
W_{β_P}
q_{P-3}
q_{P-2}
q_{P-1}
q_P

FIG. 31

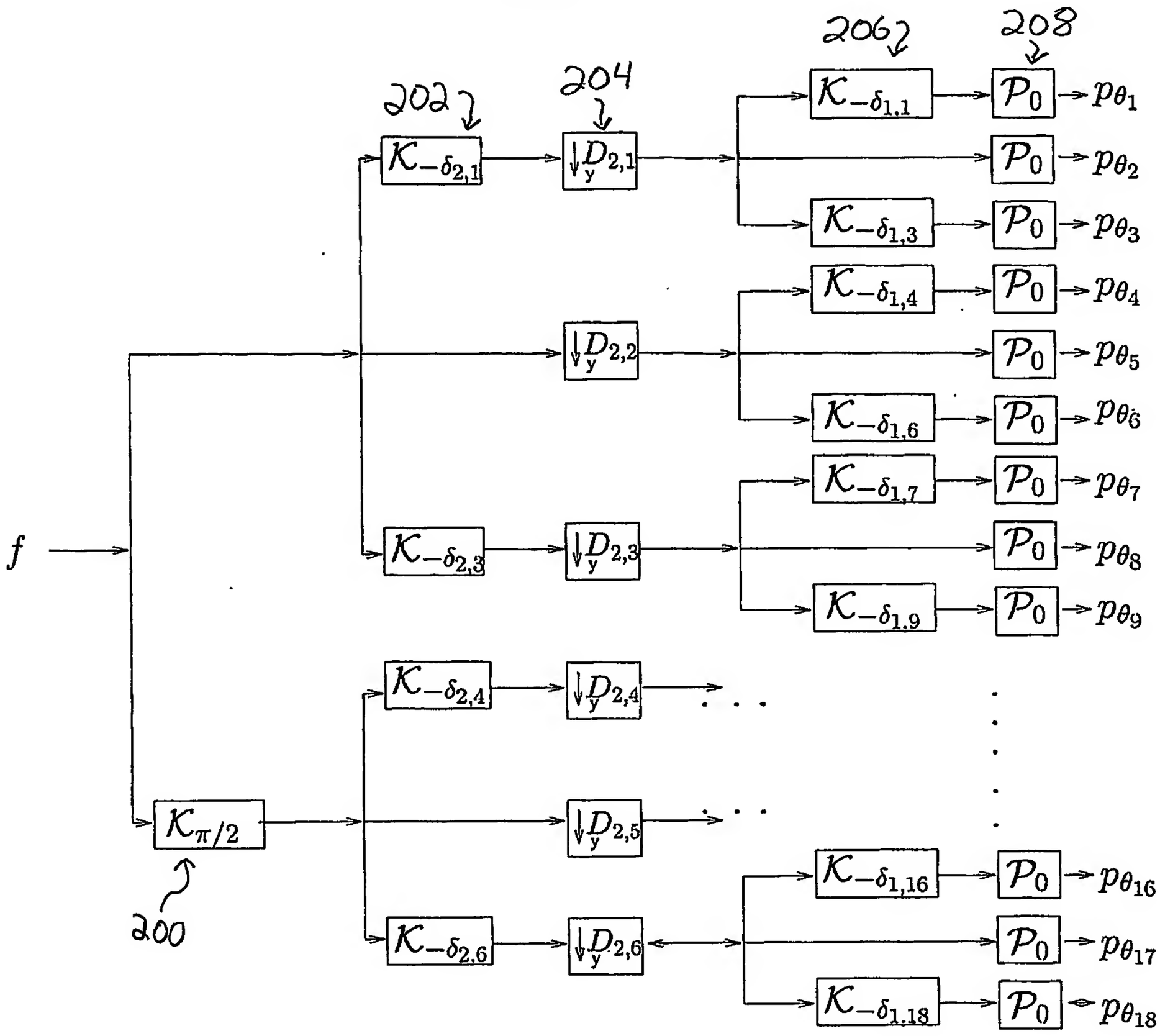

f
200
$K_{\pi/2}$
202
$K_{-\delta_{2,1}}$
$K_{-\delta_{2,3}}$
$K_{-\delta_{2,4}}$
$K_{-\delta_{2,6}}$
204
$\downarrow_y D_{2,1}$
$\downarrow_y D_{2,2}$
$\downarrow_y D_{2,3}$
$\downarrow_y D_{2,4}$
$\downarrow_y D_{2,5}$
$\downarrow_y D_{2,6}$
206
$K_{-\delta_{1,1}}$
$K_{-\delta_{1,3}}$
$K_{-\delta_{1,4}}$
$K_{-\delta_{1,6}}$
$K_{-\delta_{1,7}}$
$K_{-\delta_{1,9}}$
$K_{-\delta_{1,16}}$
$K_{-\delta_{1,18}}$
208
P_0
p_{θ_1}
p_{θ_2}
p_{θ_3}
p_{θ_4}
p_{θ_5}
p_{θ_6}
p_{θ_7}
p_{θ_8}
p_{θ_9}
$p_{\theta_{16}}$
$p_{\theta_{17}}$
$p_{\theta_{18}}$

FIG. 32

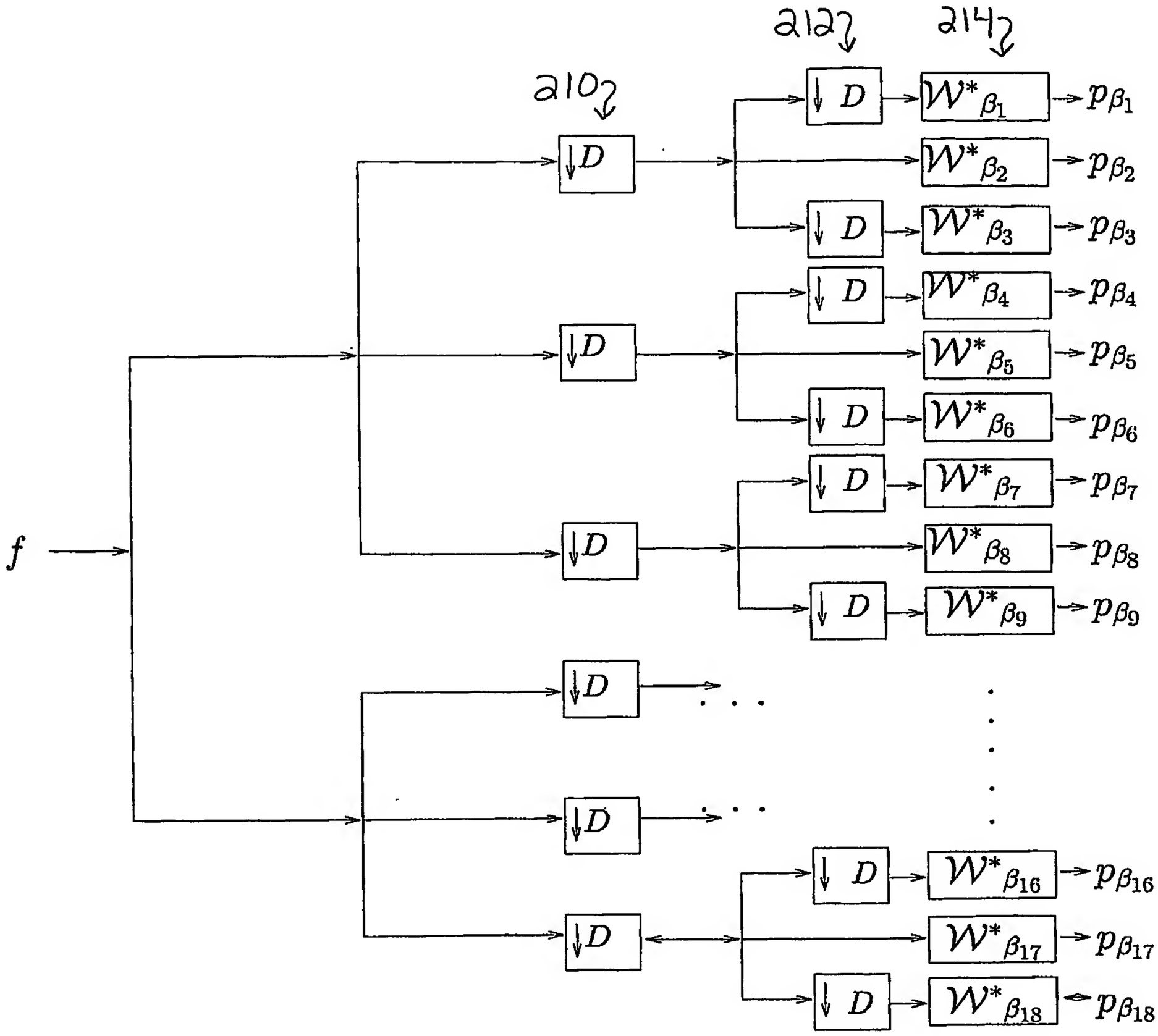
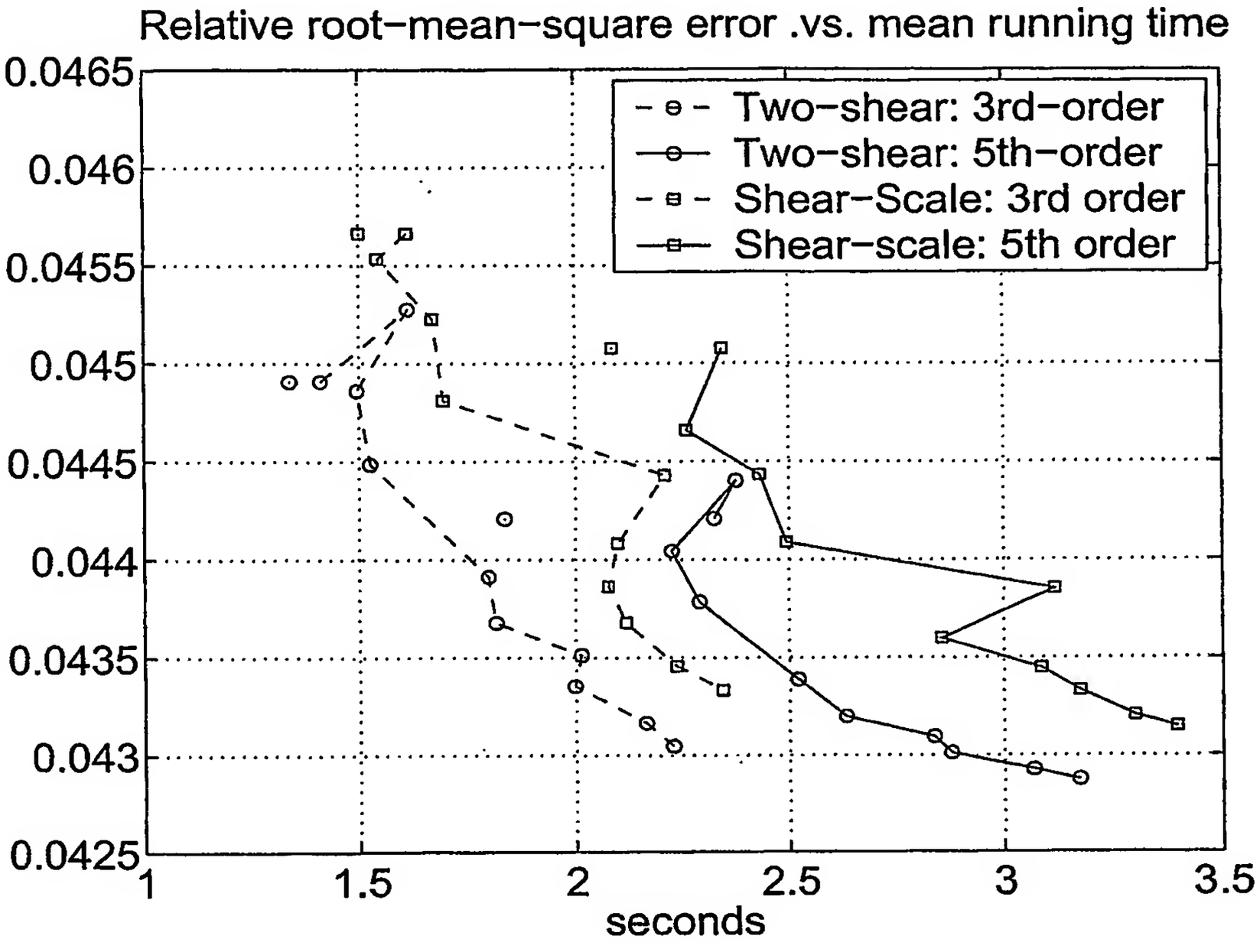

210
212
214
f
$\downarrow D$
$W^*_{\beta_1}$
$W^*_{\beta_2}$
$W^*_{\beta_3}$
$W^*_{\beta_4}$
$W^*_{\beta_5}$
$W^*_{\beta_6}$
$W^*_{\beta_7}$
$W^*_{\beta_8}$
$W^*_{\beta_9}$
$W^*_{\beta_{16}}$
$W^*_{\beta_{17}}$
$W^*_{\beta_{18}}$
p_{β_1}
p_{β_2}
p_{β_3}
p_{β_4}
p_{β_5}
p_{β_6}
p_{β_7}
p_{β_8}
p_{β_9}
$p_{\beta_{16}}$
$p_{\beta_{17}}$
$p_{\beta_{18}}$

FIG. 33

FIG. 34


Relative root−mean−square error .vs. mean running time
Two−shear: 3rd−order
Two−shear: 5th−order
Shear−Scale: 3rd order
Shear−scale: 5th order
0.0465
0.046
0.0455
0.045
0.0445
0.044
0.0435
0.043
0.0425
1
1.5
2
2.5
3
3.5
seconds

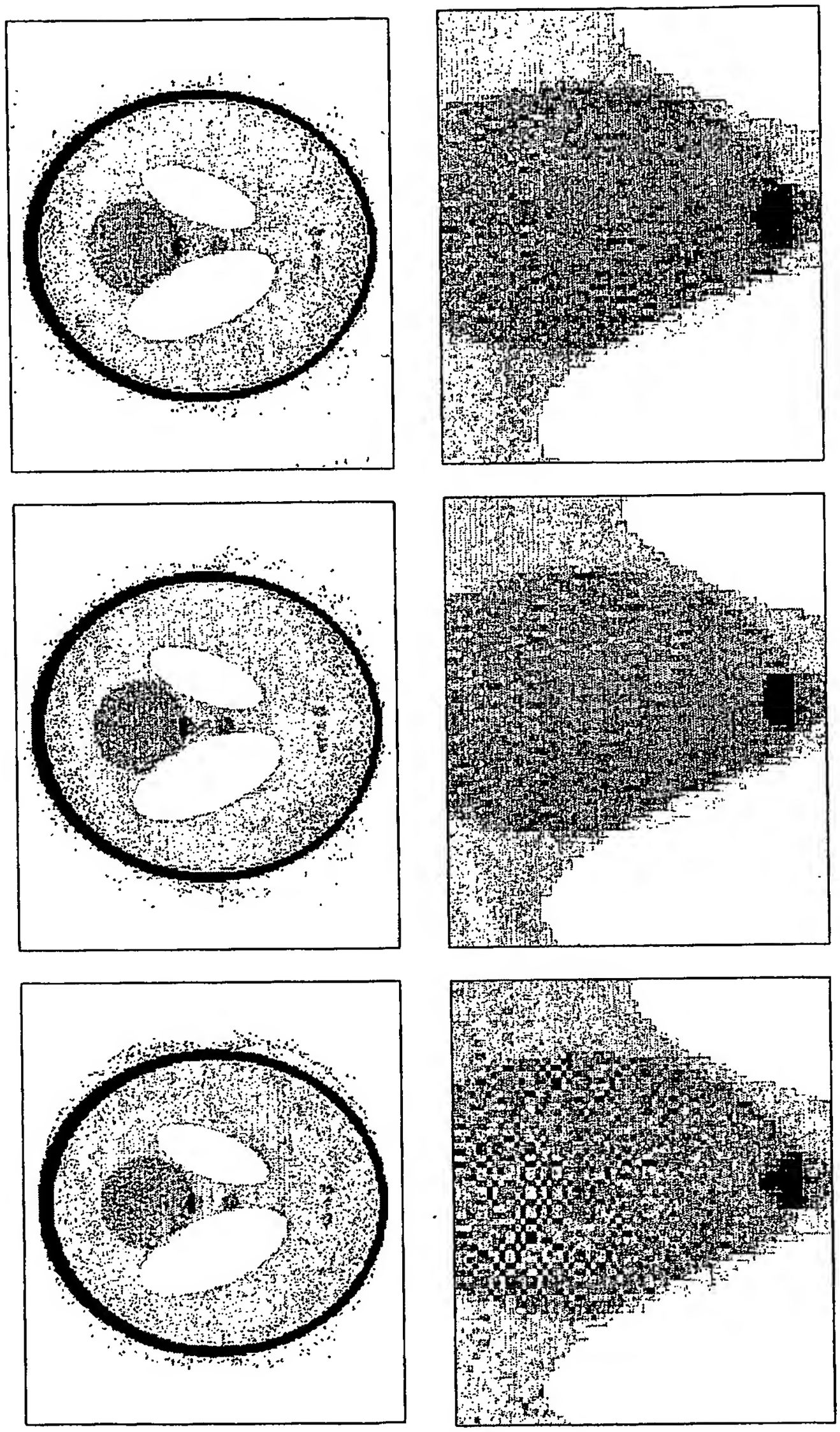


FIG. 35

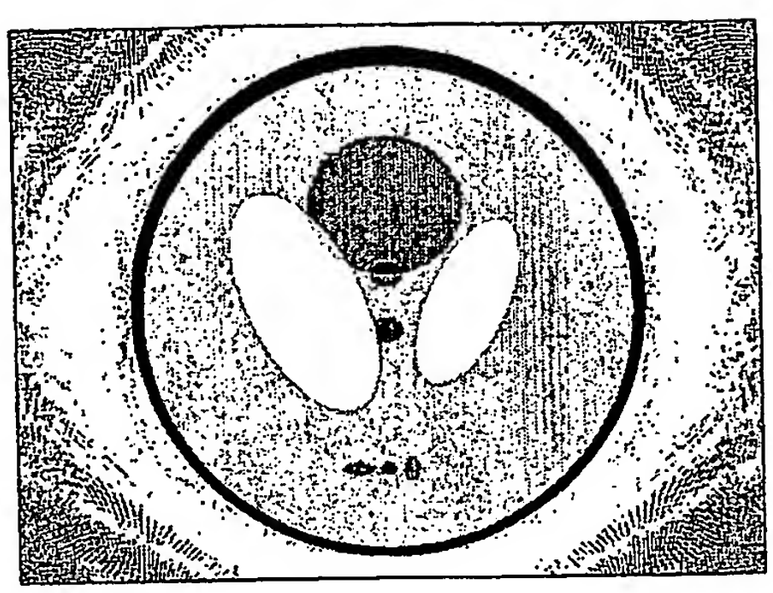


FIG.36A

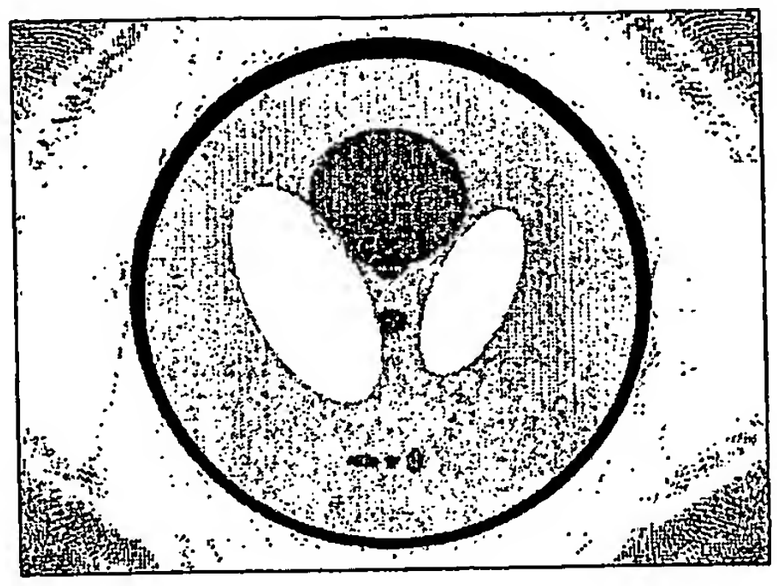


FIG.36B

FIG.37A

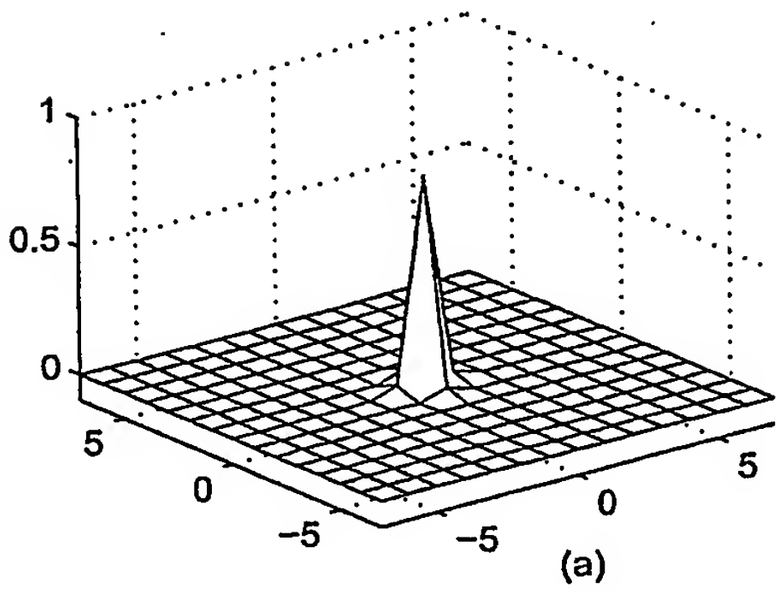
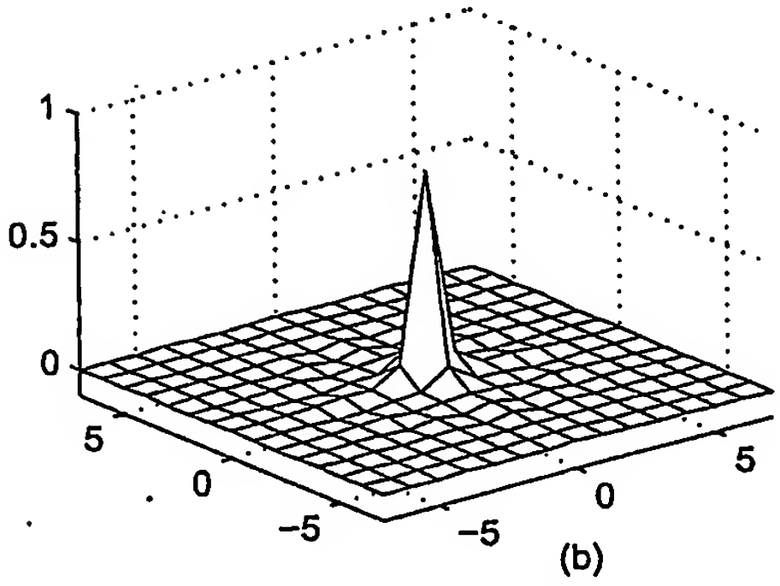


FIG.37B



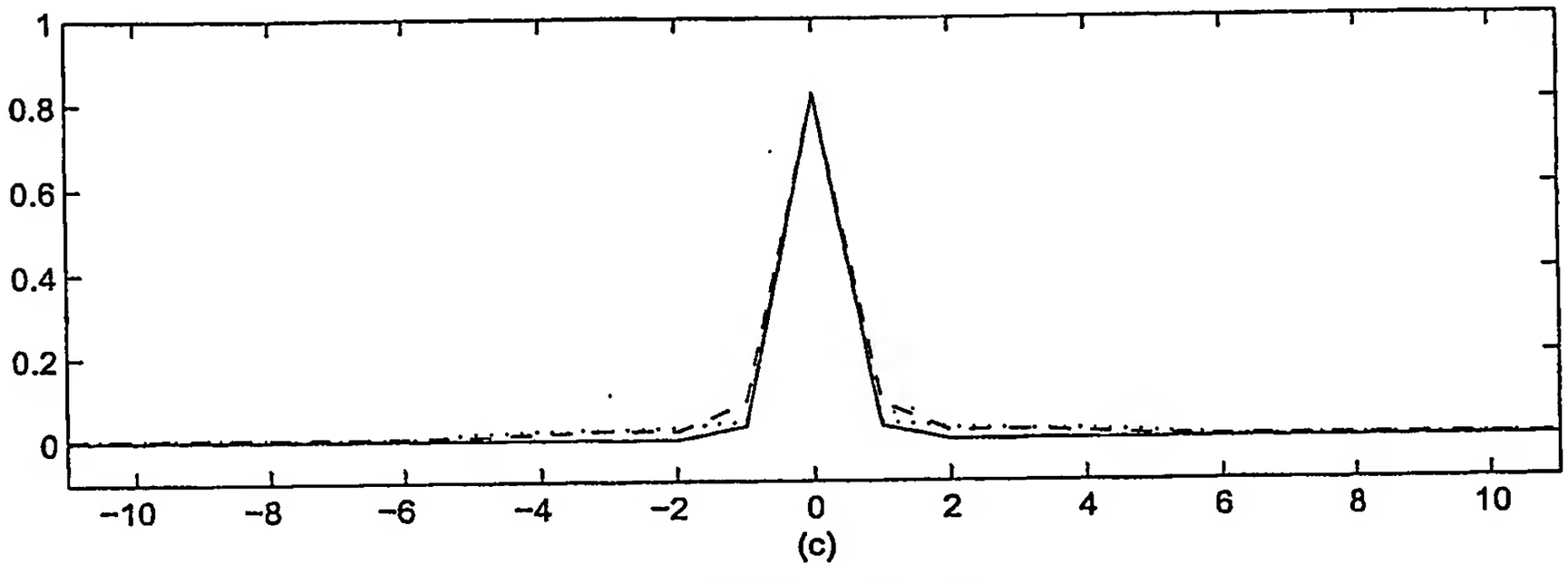


FIG.37C